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An interactionist approach in the study of organisational structuring and the identification of recurring patterns in the decision-making process

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AN INTERACTIONIST APPROACH IN THE STUDY OF ORGANISATIONAL STRUCTURING AND THE IDENTIFICATION OF RECURRING PATTERNS IN THE DECISION-MAKING PROCESSES

Submitted by

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Abstract

This thesis is concerned with the extension and application of theory of organisations to the unique demands of structuring project organisations in the construction industry. The better understanding of current practices and the recognition of environmental and technological variables as major determinants of organisation can bring insight into the process of structuring and can be the basis for diagnosing the causes of problems. Knowledge about influences on structure can assist the development of an effective design process and the ultimate improvement of the project performance.

In the first chapter, the established approaches to organisational analysis and decision-making processes are represented by the prescriptive and descriptive theories. The discussion of these particular theories are intended for the development of models and propositions as a framework for data collection and analysis, since models distilled from theory help to deduce explanations from facts and to increase understanding of events. The propositions derived from the decision-making models are used to find their conformity with the actual decision processes for the formulation and identification of a dominant model. In addition, some of the fundamental concepts associated with the contingency model with its implied interactionist perspective are examined to generate predictive hypotheses concerning the impact of environment and technology on structure. In the second chapter, the description of the projects and their contract delivery systems are presented. The data represents a sample of cross-sectionally selected building and civil engineering projects, collected by means of interviews with the corresponding contracts managers who are in the position of

authority in the site organisations. In the third and fourth chapters, the dimensions of environment and technology are discussed in the form of case studies to determine their implied structural characteristics for a comparison with the formal structures of site organisations and the actual design parameters.

The final chapter includes the summary of discussions and the conclusion. The results indicate that the evidence of any fit between the environmental and technological dimensions and the design parameters are shown to be dependent on an elongated set of processes. A shift in environmental or technological conditions leads to disequilibrium which produces a decline in effectiveness and creates pressure for change, resulting in structural adaptation to a new structure and restoring effectiveness. However, a move towards a rational process in decision-making and a consistency among contingency factors and the design parameters are often dependent on the available data regarding the situation and the time. The dominant process in structuring appears to be the frequent adaptation of past structures, particularly when quick responses are sought, explained in terms of interactions of deterministic and voluntaristic processes to retain a preferred organisational configuration.

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Chapter One

1.1 ORGANISATIONAL STRUCTURING AND STRATEGIC DECISIONS

The fundamental task of any upper-level management involves the strategic decisions that identifies and resolves the most important problems concerning the organisation's ability to survive and perform. Despite the vast range of contributions, the study of decision-making theory has remained highly fragmented, with some writers focusing on the decision-making processes (Simon, 1947), while others examined actual decisions and the outcomes of such processes (Dahl, 1961). Even those who concentrated on processes could be further sub-divided between those who adopted a psychological approach, viewing the individual as an information processing system and stressing the constraints of bounded rationality, and those who saw decision-making more as a political process involving conflict between people and subunits holding varying degrees of power (Crozier, 1964). Many of these disparate threads were drawn together and crystallized in the work of Thompson and Tuden (1964) in their simple yet highly perceptive matrix on decision strategies. Thompson and Tuden argued that if outcome preferences and beliefs about cause and effect are certain, then decision-making is a simple computational procedure. If preferences are uncertain, but beliefs about cause and effect are certain, a compromise strategy may apply. If preferences are certain, but cause and effect beliefs uncertain, a judgemental procedure will be required; but if uncertainty exists on both counts, then only inspiration can provide an answer. Such a model is an abstraction and it is not suggested that all decisions fit neatly into it, but rather that they will approximate to different cells. The aim of management therefore is to maximize the number of decisions where the outcome can as far as possible be accurately determined and calculated, and reduce dependency on compromise, judgement and inspiration.

Astley et al. (1982), building on Thompson, proposed a model which argues that decision-making may vary in terms of complexity and politicality. Complexity refers to the extent to which the topic is intricate and may involve multiple considerations, and is likely to be greater in the case of innovative decisions. Politicality, on the other hand, involves the political dimension in decision-making, for irrespective of complexity each topic is subject to the diverse and often conflicting views of various interests. When taken together, these provide a dual description of variability of decisions in a decision-making arena.

According to conventional dogma, it is possible to identify two primary categories of decision-making processes with multiple perspective which together and with their various offshoots and derivatives constitute the bulk of the available literature on organisational theory and analysis. They are the descriptive (or behavioural) theories that try to describe actual behaviour of individuals in organisational settings, and the prescriptive (or rational) theories that correspond to the classical economic view of decision-making which is grounded in rationality, optimality and consistency (Allison, 1971) and assumes that decisions emerge from a process of conscious choice. The two categories have developed as a dialectic rather than as separate domains and are represented by models with varying assumptions and inherent biases. These models help to group certain recurring patterns and allow for the formulation of decision processes in the context of organisational structuring, and have been identified as the adaptation model, the behaviour choice model, the organised anarchy model, the political model and the contingency model.

1.2 BEHAVIOURAL DECISION THEORY

The first major integration of decision theory and organisational behaviour was introduced by March and Simon (1958) in a series of theoretical statements about the decision-making behaviour of individuals, groups and organisations. The major premise of their theory is that decision-making is the fundamental process of behaviour and performance within organisations. These authors define an organisation as a structure of decision-makers acting at times as individuals and at other times as groups. The behavioural view argues that the actual decisions are made under conditions of bounded rationality which implies that individuals make decisions under a number of external and psychological constraints, thus creating a number of important implications about the process. First, decision-makers tend to make decisions in sequence; that is, if the individual or group is satisfied with present conditions, no search is made for more or better alternatives. Second, decision-makers use the most convenient and least expensive information, since information is not a free commodity and is not readily available in usable form. Third, the direction of the decision-makers' search for alternative actions is often influenced by personal perceptions and experiences. On further development of this theory, Cyert and March (1963) proposed a model based on four abstract concepts of quasi-resolution of conflict, uncertainty avoidance, problemistic search and organisational learning which guide the decision process as depicted in Figure 1.1. To provide a basis for generation of hypotheses, the selected models from the first classification that take a behavioural rather than a rational approach towards decision-making are discussed in the following paragraphs.

FIGURE 1.1

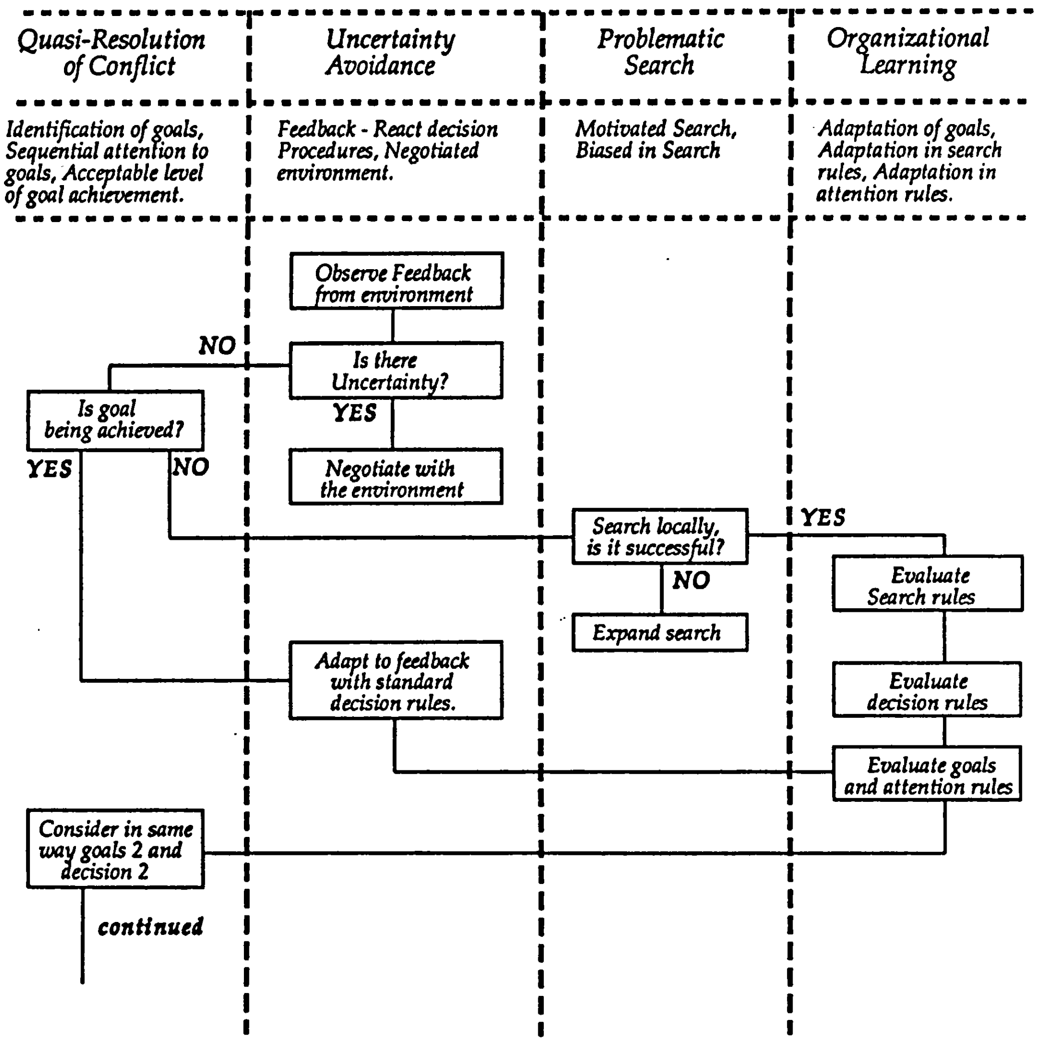


FIGURE 1.1 Organizational Decision Process in Abstract Form (Cyert and March 1963)

1.3 ADAPTATION MODEL

The adaptation model involves the notion of change and adaptive behaviour; that is, an action is taken, the world responds to the action, and the individual infers something about the world and adapts his behaviour so as to secure desirable responses. The decisions are often guided by calculation of the benefits and costs anticipated from alternative actions reflecting the combination of two guesses about the estimate of probable future states of the world and the probable future values. The model suggests that maintaining a shared social perception of, or consensus about, the state of the world (organisation) is not the more important criterion but that change must be introduced incrementally consistent with the cyclical process of learning.

1.3.1 The Adaptation Assumptions

Most efforts to rationalise observed behaviour have attempted to place that behaviour within a framework of calculated rationality. Although presumptions of rationality both as an objective and as a reality are still common, the literature is full of attempts to develop the major implications of limitations on the awareness of alternatives, on the precision of information about consequences, and on the clarity and consistency of goals (Simon, 1955; March and Simon, 1958). There is an inclination to accept the proposition that while organisations are intendedly rational, they frequently act on incomplete or incorrect information and without being aware of all of their alternatives. Similarly, the general acceptance of a simple view of a well-defined organisational preference function is replaced by an effort to accommodate in the theory the frequent observations of inconsistent and conflicting organisational objectives.

Learning is ordinarily understood in terms of a model of simple rational adaptation. Ideas of adaptive rationality emphasise experiential learning by individuals or organisations. Most adaptive models have the property that if the world and preferences are stable and the experience prolonged enough, behaviour will approach the behaviour that would be chosen rationally on the basis of perfect knowledge. However, the postulated learning functions normally have properties that do not permit sensible adaptation to drifts in environmental attributes (March, 1988). The adaptation model recognises the constraints on human action and the ambiguous and conflicting conditions in which the causality of events is difficult to untangle. Such a focus does not suggest that individuals or organisations are conspicuously foolish in their learning, but that organisational rigidities and cognitive and evaluative limitations on rationality systematically affect what is learned.

The theory describes the individual as having a certain probability of selecting an alternative and deals with the way these probabilities and the individual's behaviour change as a consequence of the occurrence of one of the possible events. The process of adaptation, as represented by the model, can be simplified by the following sequence of assumptions:

(1) Alternative behaviours - the model starts with the assumption that any individual has a possible set of mutually exclusive alternatives that are concerned with a decision situation.

(2) State of the individual - the individual is in some state with respect to the alternative behaviours that are described by a set of probabilities. As the adaptation proceeds, these probabilities are changed so that at some subsequent point in time they need revising.

(3) Alternative responses - it is assumed that the world (environment) has a set of possible responses to the behaviour of the individual.

(4) State of the world - the world has some set of rules for its own behaviour which together with the set of responses describe the environment for adaptive behaviour.

(5) Set of possible events - assumptions (1) and (3) provide a complete enumeration of all the possible events that can occur, and from the assumptions with respect to the state of the individual and the state of the world the likelihood of each event can be estimated.

The above sequence of assumptions suggest that adaptation results neither from extraordinary organisations processes or forces, nor from uncommon persistence or skill, but from relatively stable and sometimes routine processes of change that relate the organisations to their environment. However, the fundamental argument should be seen as one of responsiveness and not one of stability in behaviour. Although organisations may appear resistent to change, they are remarkably adaptive, enduring institutions, responding to volatile environments routinely, but not always optimally (March, 1981).

1.4 BEHAVIOUR CHOICE MODEL

Simon (1956) bears substantial intellectual responsibility for the development of the behaviour choice model. Although it can be argued that the empirical and theoretical efforts of the past thirty years have brought us closer to understanding decision processes, it is clear that there is not a single, widely accepted and precise definition to explain the theory. This understanding is organised in a set of conceptual elements with tenuous connections rather than a single and coherent structure. Some major aspects of key processes that appear to be reflected in the model have been identified, but the precise nature of those processes and their interaction are not fully captured by any current theory. The behavioural view of choice uses ideas regarding calculated rationality, information processing, preference processing, search and satisficing.

1.4.1 Calculated Rationality

Most efforts to rationalise observed behaviour have attempted to place that behaviour within a framework of calculated rationality. The usual argument is that a naive rational model is inadequate either because it focuses on the wrong unit of analysis, or because it uses an inaccurate characterisation of the preferences involved. As a result, the ideas of limited rationality, process rationality and game rationality have been developed.

Ideas of limited rationality emphasise the extent to which individuals and groups simplify a decision problem because of the difficulties of anticipating or considering all the alternatives information (March and Simon, 1958). They introduce, as reasonable responses, such things as simple search rules, uncertainty avoidance, working backward, and a host of elaborations of such ideas to simplify decision problems.

Ideas of process rationality emphasise the extent to which decisions find their sense in attributes of the decision process, rather than in attributes of decision outcomes (Cohen and March, 1974). Explicit outcomes are viewed as secondary and decision-making becomes sensible through the intelligence of the way it is orchestrated.

Game rationality describes organisations and other social institutions as consisting of individuals who act in relation to each other intelligently to pursue objectives by means of individual calculations of self-interest.

These ideas are theories of intelligent individuals making calculations concerning the consequences of their actions, and acting sensibly to achieve their objectives. Action is presumed to be consequential, to be connected consciously and meaningfully to knowledge about personal goals and future outcomes, and to be controlled by personal intentions.

1.4.2 Information Processing

An area of concern in the behavioural theory of choice is the question of how individuals and groups utilise information in making decisions and arriving at evaluative judgement. This area treats decision-making as an information-processing activity and attempts to predict the decisions made by people from a knowledge of the way they handle information. Suppose that an organisational analyst examines the decisions of an organisation focusing on (1) the information actually used; (2) the relative importance placed on each piece of information; and (3) the fashion in which the information is combined. Determining the strategy a decision-maker has followed with respect to the above items is called policy capturing. The purpose of policy capturing is to diagnose the strategy implicit in one's decisions and improve the quality of such decisions by making the strategy explicit. The policy capturing in organisations is sometimes called heuristics, which is the attempt to describe the process by which a decision is made and from such knowledge improve the accuracy of such decisions.

1.4.3 Preference Processing

Rational choice involves two kinds of guesses; guesses about future consequences of current actions and guesses about future preferences for those consequences. We try to imagine what will happen in the future as a result of our actions and we try to imagine how we shall evaluate what will happen. Neither guess is necessarily easy. Anticipating future consequences of present decisions is often subject to substantial error, and anticipating future preferences is often confusing. Theories of choice are primarily theories of these two guesses and how we deal with their implications.

The behavioural inquiry into preferences is based on the following assumed features: individuals commonly find it impossible to express both a preference (or a taste) for something and a recognition that the taste is repugnant to standards they accept. Choices are often made without respect to preferences and decision-makers routinely ignore their own, fully conscious, preferences and follow rules, traditions and the advice or actions of others. Preferences change over time in such a way that predicting future preferences is often difficult. As we contemplete making choices, we know that our attitudes about possible outcomes will change in ways that are substantial but not entirely predictable. Many preferences are stated in forms that lack precision and it is difficult to make them operational in evaluating possible outcomes. Whilst tastes are used to choose among actions, it is often also true that actions and experience with their consequences affect tastes. Based on the above features it can be stated that generally human preferences have the properties which can be characterised as irrelevant, unstable, endogenious, inaccurate and not absolute.

1.4.4 Search

Limited rationality motivates organisational search, and under this view, decision-making takes place through problem solving, search and trial and error. *"The intelligence of organisational action is seen as not lying about the capability to know everything in advance but in the ability to make marginal improvements by monitoring problems and searching for solutions" (March 1981).*

Search motivation is a function of performance and aspiration levels. Individuals and organisations form aspirations, goals, or ambitions for achievement. These ambitions are usually assumed to be connected to outcomes since they affect search either directly or through some variable like motivation, and thus influencing performance and affecting satisfaction (March and Simon, 1958). The level of personal ambition is not a decision variable in most theories of choice, but as a result of the work by many researchers on satisficing, there has been some interest in optimal levels of aspiration. These efforts consider an aspiration level as a trigger that either begins or ends the search for new alternatives. The optimisation problem is one of balancing the expected costs of additional search with the expected improvements to be realised from the effort.

1.4.5 Satisficing

The concept of satisficing was first introduced by Herbert Simon (1957) as the acceptance of alternatives that are satisfactory in meeting or exceeding imposed criteria rather than alternatives that are optimal. This concept suggests that individuals, groups and organisations rarely maximise goal attainment in their decisions, instead they tend to evaluate decision alternatives against standards that set minimally acceptable levels of attainment for each objective rather than maximum standards. If a decision alternative is found to be minimally acceptable with respect to standards, it is chosen and a search for additional alternatives or strategies is discontinued.

March and Simon (1958) state: "*Most human decision-making, whether individual or organisational, is concerned with the discovery and selection of satisfactory alternatives; only in exceptional cases is it concerned with the discovery and selection of optimal alternatives*".

1.5 ORGANISED ANARCHY MODEL

The main concept of organised anarchy is developed around two basic ideas of activation process and ambiguity of relevance (Cohen, March and Olsen, 1972). Every participant constantly faces the personal problem of allocating his attention among competitive claims on his time. On one hand, it may be assumed that many decision-makers in contemporary organisations are overloaded, that tasks alone can consume more time than many participants have. On the other hand, participants also must play other roles as members of local, national and sometimes international communities. As a result, the character and outcome of any decision process in an organisation is dependent on external and internal demands on the time of various participants. It is proposed that an important aspect of any decision is the attention pattern of people who are potentially concerned with decisions. This pattern is only to a limited degree a function of the properties of the decision itself and it partly depends on other activated concerns and their relative pressure for attention. If it can be assumed that most participants are operating most of the time at their capacity, increasing the average attention load will have some obvious effects, such as decreasing the amount of energy available for any one problem. Therefore, in order to obtain the same amount of attention, either the length of time taken to reach a decision must be increased or the number of persons involved, otherwise the total amount of attention to the problem must be reduced.

The average load on potential participants is particularly susceptible to the properties of participants. Relatively important participants tend to be more heavily loaded than relatively unimportant ones. Importance here refers to the mix of attributes most commonly associated with social and organisational status. One possible consequence of this differential loading stems from the fact that when a choice situation is defined as an important one, it automatically tends to involve important people. As a result of high average load on such people, important decisions often have difficulties securing enough attention. Therefore, the theory attends to the process of activation where the number and type of participants activated together with the attention patterns become major determinants of a decision process.

The second idea is the ambiguity of relevance. The concept of choice assumes some relatively straightforward procedure by which individual's preferences and cognitions are aggregated into organisational choices. The postulated procedure associates relevant solutions with appropriate problems and assumes that the criteria of relevance are clear. Objectives can be stated reasonably precisely, alternatives can be studied by looking at outcomes, and there is a stable division of labour by which certain individuals and groups specialise in certain decisions. Although relevance criteria may be quite precise within a decision context, the extent to which choice situations involve problematic goals, unclear technologies and fluid participation have been often underestimated. Preferences are often problematic and it is difficult to consider a set of preferences to a decision situation that satisfies the standard consistency requirements for a theory of choice. Organisations operate on the basis of a variety of inconsistent and ill-defined preferences, which can be described as a loose collection of ideas without a coherent structure. Technology is often unclear and although organisations manage to survive, their own processes are not understood by the members. They operate on the basis of simple trial and error and the residue of learning from the accidents of past experiences. Participation is often fluid and participants vary in the amount of time and effort they devote to different domains. As a result, the boundaries of organisations are uncertain and changing and decision-makers for any particular kind of choice change capriciously. These properties have been identified in studies of organisations and describe some aspects of almost any organisation's characteristics.

1.5.1 The Basic Process

In the organised anarchy the process of decision-making concerns itself with a relatively complicated interplay among the generations of problems in an organisation, the deployment of personnel, the production of solution and the opportunities for choice. This process can be viewed as a basket into which various kinds of problems and solutions are dumped by the participants as they are generated. The mix of content in a single basket depends on the number of baskets available, on what solutions are currently being produced and on the speed with which baskets are collected and removed from the scene. Therefore, the participants move from one choice opportunity to another in such a way that the nature of the choice, the time it takes, and the problems it solves all depend on a relatively complicated intermeshing of elements with their own dynamics. These include the mix of choices available at any one time, the mix of problems that have access to the organisation, the mix of solutions looking for problems, and the outside demands on the time of decision-makers.

1.6 POLITICAL MODEL

The essence of the political model is the subjective construction of reality and that all social and political interaction involves an exercise of power. Despite the existence of a great variety of definitions of power in the behavioural science literature, there is a lack of agreement among social scientists as to what precisely constitutes power. As Cartwright (1959) noted, most authors have taken pains to provide a definition but each felt compelled to invent one of his own. The consequence is that a wide variety of definitions exist. For example, Bierstedt (1950) looked at power as a hidden capacity which makes the application of force possible. Others like Blau (1964) and Dahl (1957) have focused on the more manifest nature of the concept, the latter defining power of person A over person B as the extent to which he can get B to do something that he would not otherwise do. Also, writers such as Dahl have primarily studied power at the individual level, while others such as Parsons (1960) has studied power mostly at the organisational level. For example, to Parsons, power is the realistic capacity of a system unit to actualise its interests within the context of system interaction and in this sense exert influence on processes in the system to attain specific goals.

Although some of the past research on power has focused on the impact of authority on structure such as centralisation, standardisation and formalisation or other structural aspects including the organisational hierarchy, more relevance is attached to the subjective use of power and the formation of coalitions to construct a political view of the decision-making processes. Coalitions are politically motivated to support one view of a problem over other views since the way the nature of the problem is resolved have an impact on the way future resources are allocated. Hence, coalitions use their own histories and experiences to construct a view in the light of their own domain or interest. This cooperative strategy involves conscious agreements between various individuals or groups to acquire power and is based on the assumption that it is best to minimise conflict and debate by coalescing support and power behind one view (Pfeffer, 1981).

Power can also be enhanced by the characteristics of the target and the situational factors. For example, personality characteristics have been shown to be related to individuals susceptibility to power influence. Individuals with a low tolerance for ambiguity or with little self-confidence are easily influenced by others. The illusion of control (Langer, 1975) is another important factor, since those who possess special skills or those who are perceived as experts are influential in determining which view of the problem is accepted. Uncertainty, as a situational factor, is not a determinant of power but the ability to cope with and control uncertainty is. The life blood of any organisation is the certainty with which inputs and resources can be transformed into goods and services, and those individuals or groups that can cope with uncertainties facing the organisation accrue the most power.

1.7 RATIONAL DECISION THEORY

The rational decision theory is related to a series of assumptions that assert the essentiality of organisations as instruments for the attainment of clearly specified goals. Associated with the notion of rationality is the systems approach to understanding organisations. The term system refers to an entity with interdependent parts which are linked together as a collection of interacting elements. A 'closed' system is wholly comprehensible, since the activities can be broken down into separate parts for the identification of their systemic relations and the inner workings. Another perspective in the systems approach is a gradual shift of emphasis towards the conception of organisations as adaptive 'open' systems dependent on a continual interchange with the environments in which they operate.

The move toward open systems has produced in the opinion of many a related swing towards contingency or situational design of organisations. Building on a systems philosophy and emphasising the complex interaction between environment, task, technology, human motivation and structure, contingency theory suggests that there is no one best way to organise or manage an organisation. Rather, the most appropriate style will be dependent upon the particular demands of the situation which will vary from one organisation to another. Woodward (1965) suggested that there is an empirical relationship between the nature of production systems, technology and patterns of organisation, and that it is the technical methods that are the primary factor in determining organisational form. Burns and Stalker (1961) illustrated how different technologies call for different organisational designs and differentiated mechanistic from organistic structures, arguing that firms in relatively stable environments impose quite different structural requirements to those operating in more complex and rapidly changing environments. Lawrence and Lorsch (1967) continued the popularisation of the so-called contingency approach with their study of the structure and functioning of organisations in stable and dynamic environments. Several other lines of research have contributed to this perspective to the point where Child (1977) described it as the dominant approach in the study of organisations.

The critiques of the systems approach argue that organisations attempt to be rational, controlling their internal operations and environments to the greatest extent possible, but never achieving a totally closed, rational system. How well the organisation achieves rationality depends upon the strength of the internal and external pressures and the organisation's ability to control the events. The contingency model provides a rational approach in structuring of organisations and uses both the closed and open systems as a single analytical framework.

1.8 CONTINGENCY MODEL

Thompson (1967) saw the emergency of a new perspective in which organisations were viewed as open systems subject to environmental and technological conditions, a perspective departing from the traditional practice of endorsing or prescribing an ideal, universal type of organisation (Linkert, 1967; McGregor, 1962). More current empirical investigations (Galbraith, 1973; Mohr, 1971; Duncan, 1971; Lawrence and Lorsch, 1967) provide evidence to support the new perspective which relies on a few explicitly stated assumptions. The first assumption is that there is no one best way to organise. The second is that any way of organising is not equally effective under all conditions. The theory then asserts that in order to be most effective organisations should consider the structural consequences resulting from variable states of environment and technology.

Galbraith (1973) argued that the structure of organisations is dependent upon the amount of information processed among the decision-makers during task execution and on the relative costs of various structural designs. One of Galbraith's basic assumptions is that the greater the uncertainty of the task, the greater the information that must be processed during task execution to achieve a given level of performance. As a consequence, the specific organisational and sub-unit structures adopted should reflect the degree of uncertainty present in the task. Galbraith states: *"All lead to the conclusion that the best way to organise is contingent upon the uncertainty and diversity of the basic task being performed by the organisational unit"*. Galbraith formalised and presented his arguments as multiplicative hypotheses expressing the interaction of technological uncertainties with structural variables and their influence on organisational effectiveness. For example, he asserted that any increase in uncertainty inflates the volume of information required at the point of task execution, increasing the exercise of workforce participation in decision-making.

Although the contingency theory is considered as a collection of approaches that cannot offer a specific definition of the contingency view of organisation in a single model, it contains a unifying idea proposed by Burns and Stalker (1961) that: *The beginning of administrative wisdom is the awareness that there is no optimum type of management system"*.

1.8.1 Concept of Environment

Duncan (1971) defined environment as the interaction between the system's internal and external components. They consist of those relevant physical and social factors inside or outside the boundaries of the organisation that have direct influence on the decision-making behaviour of individuals and decision units (Table 1.1). In order to make predictions about the kinds of environments in which different levels of perceived uncertainty are expected to exist and their consequent structural demands, Duncan (1971) identified two dimensions of environment which are represented along two continuums of simple-complex and static-dynamic.

The simple-complex continuum deals with the degree to which the components of environment influencing the decision situations are few in number and similar in nature or are many in number and different. The static-dynamic continuum indicates the degree to which the components remain basically the same over time or are in a continual process of change. Figure 1.2 provides a four-way classification of organisational environments. Complex-dynamic (cell 4) environments are probably the most characteristic type of environments in the construction industry involving rapid change and unanticipated decision situations.

Many researchers have tended to combine the two dimensions together, since they often move in tandem, and so have been unable to distinguish their individual effects on structure. In his research, Duncan (1971) was able to show that, at least in terms of managerial perceptions, the two dimensions are distinct and uncertainty in decision-making is related to

TABLE 1.1

Internal Environment

(1) *Organisational personnel component*
- (a) *Educational background and skills*
- (b) *Previous managerial skills*
- (c) *Interpersonal behaviour skills*
- (d) *Availability of manpower for utilization within the system*

(2) *Organisational functional and staff units component*
- (a) *Technological characteristics of organizational units*
- (b) *Interdependence of organizational units in carrying out their objectives*
- (c) *Conflict among organizational functional and staff units*

(3) *Organizational level component*
- (a) *Organizational objectives and goals*
- (b) *Nature of the organization's product service*

External Environment

(4) *Customer component*
- (a) *Distributors of product or service*
- (b) *Actual users of product or service*

(5) *Suppliers component*
- (a) *New materials suppliers*
- (b) *Equipment suppliers*
- (c) *Labour supply*

(6) *Competitor component*
- (a) *Competitors for suppliers*
- (b) *Competitors for customers*

(7) *Socio-political component*
- (a) *Government regulatory control over industry*
- (b) *Public political attitude towards industry and its particular product*
- (c) *Relationship with trade unions*

(8) *Technical component*
- (a) *Meeting new technological requirements in production of products or services*
- (b) *Improving and developing new products and methods*

TABLE 1.1 Factors and components comprising the organizations internal and external environment (Duncan, 1971)

FIGURE 1.2

	Simple	*Complex*
Static	*Cell 1: low perceived uncertainty* *(1) Small number of factors and components in the environment* *(2) Factors and components are somewhat similar to one another* *(3) Factors and components remain basically the same and are not changing*	*Cell 1: moderately low perceived uncertainty* *(1) Large number of factors and components in the environment* *(2) Factors and components are not similar to one another* *(3) Factors and components remain basically the same*
Dynamic	*Cell 3: moderately high perceived uncertainty* *(1) Small number of factors and components in the environment* *(2) Factors and components are somewhat similar to one another* *(3) Factors and components of the environment are in a continual process of change*	*Cell 4: high perceived uncertainty* *(1) Large number of factors and components in the environment* *(2) Factors and components are not similar to one another* *(3) Factors and components of environment are in a continual process of change*

Figure 1.2 Four-way classification of environment and perceived uncertainty experienced by individuals in decision units

the dimension of stability rather than complexity. He stated that: "*The static-dynamic dimension of environment is a more important contributor to uncertainty than the simple-complex dimension. Decision units with dynamic environments always experience significantly more uncertainty in decision-making regardless of whether their environment is simple or complex*".

1.8.2 Concept of Technology

Although the literature does not offer a widespread consensus as to the single best definition of technology, there seems to be some convergence on certain important points concerning this concept. First, there seems to be some agreement that technology concerns either the mechanical or intellectual processes by which an organisation transforms resources into final goods or services. In other words, technology refers to the transformation process whereby mechanical and intellectual efforts are used to change inputs into outputs. Second, the diversity of opinions on a definition of technology may relate to the level of analysis at which the concept is viewed.

Perrow (1967) defined technology as an individual's direct actions on some raw material in an attempt to change it, and organisational structure as the form of an individual's interaction with co-workers. He related technological routinisation to the early recognition of problems and to the extent of standardisation of search processes when problems occur. He argued that in order to operate effectively any type of technology has certain organisational requirements which will be reflected in the pattern of sequences used in performing the tasks and the characteristics of the knowledge used in the workflow.

Woodward (1965) suggested that technology more often than size is related to variations in organisational structure. She, for example, showed that regardless of the size of the firm, there is a consistent tendency for managers and supervisors to supervise fewer workers as technological complexity increases. These assertions quickly met challenges from proponents of size as the more important determinant of organisational structure. The Aston group showed that organisational size rather than technology appear to exert the more significant influence on structure. Marsh and Mannari (1981) have also dealt with the controversy over the relative importance of size and technology. They found in their study of 50 Japanese factories that structural differentiation and formalisation are clearly more a function of size than of technology. However, supporting many earlier views of the effects of technology, their results show technology to have a more significant and stronger impact than size on span of control. They also found that some of the components of structure vary independently both of size and technology.

Thompson (1967) suggested a basic relationship between technology and organisation in the proposition that under norms of rationality organisations group the positions to minimise coordination costs. This concept explains the interdependencies among work units and the way tasks are coupled together. There are three ways in which tasks can be coupled together. First is pooled coupling, where members share common resources but are otherwise independent. Second is sequential coupling, where members work in series until a point and then merge together later in the process. Finally, in reciprocal coupling members feed their work back and forth among themselves; in effect each unit or member receives inputs from and provides outputs to the others. Pooled coupling involves the least amount of interdependence and reciprocal coupling involves the most amount of interdependence among activities.

Galbraith (1973) suggested that task uncertainty and the resultant information processing requirements provide the mechanism for technological determination of structure. He argued that reducing or increasing the information processing requirements make up the fundamental organisational design strategies. For example, when faced with high uncertainty, managers design their structures to create self-contained tasks and improve lateral relations. This would permit the organisation to make more decisions and process more information without overloading the hierarchical communication channels.

1.9 ORGANISATIONAL DESIGN

Organisational design is the process of achieving a coordinated effort through the structuring of tasks, authority and workflow. This is a conscious process to develop the most effective and stable patterns of interaction within the organisation. The result of the design is a structure that links the technology, tasks and human components through formal and semi-formal means to ensure the accomplishment of objectives.

Mintzberg's (1979) analytic approach to study the structure of organisations was to break the essential parts into four major groups or design parameters: positions, superstructure, lateral linkages, and decision-making systems (Table 1.2). In the following paragraphs these parameters together with their basic components are reviewed to provide a background for future classification of the research data and discussions on the accuracy of the hypotheses.

TABLE 1.2

Group	*Design Parameter*	*Related Concepts*
Design of Positions	*Job specialization*	* *Basic division of labour*
	Behaviour formalization	* *Standardization of work content* * *System of regulated flows*
	Training and Indoctrination	* *Standardization of skills*
Design of Superstructure	*Unit grouping*	* *Direct Supervision* * *Administrative division of labour* * *Systems of formal authority, regulated flow, informal communication, and work constellations* * *Organization*
	Unit size	* *Systems of inform communication* * *Direct supervision* * *Span of control*
Design of Lateral Linkages	*Planning and control systems*	* *Standardization of outputs* * *Systems of informal communication*
	Liaison devices	* *Mutual adjustment* * *Systems of informal communication*
Design of Decision-Making Systems	*Vertical Decentralization*	* *Administrative division of labour* * *Systems of formal authority, regulated flows*
	Horizontal Decentralization	* *Administrative division of labour* * *Systems of informal communication*

TABLE 1.2: Organizational design parameters (Mintzberg, 1979)

1.9.1 Positions

Two factors are considered in the design of positions: specialisation that allows the individual to be matched to the task, and formalisation that specifies the roles and regulates the behaviour of the individual. An inherent characteristic of any organisation is the extent to which the scope and depth of each task are identified. The former refers to the number of elements that are involved in a job and different activities that an individual performs within a certain cycle of work. The latter refers to the relative freedom the individual has in planning, organising and controlling the assigned duties. It has been assumed that the greater the degree of specialisation, the greater the demands for participation in organisational decision-making. Skilled individuals demand not only more job autonomy, but more power in general. Conversely as the job occupants in an organisation demonstrate more competence and expertise, people with power are more likely to consult with them, thus sharing decision-making to a greater degree.

Formalisation of behaviour is the design parameter by which the work processes of an organisation are standardised and the extent to which rules, procedures and instructions are written. The simplest method of coordinating interdependent subtasks is to specify the necessary behaviours in advance of their execution in the form of rules or programmes. The primary virtue of rules is that they eliminate the need for further communication among various subunits. To the extent that the job-related situations can be anticipated in advance, rules can be devised to guarantee the integration of activities without communication. These rules and programmes eliminate the need for treating each situation as new, reducing the amount of communication required each time a situation is repeatedly encountered. There are three ways of formalising behaviour: formalisation by job, formalisation by rules, and training and indoctrination. Formalisation by job implies that the organisation attaches behavioural specification to the job itself, documenting it in formal job descriptions, and telling employees what steps to take in their work, in what sequence and when. Formalisation by rules implies that the organisation uses rules for all situations to regulate the behaviour of employees to reduce variability, to coordinate activities and to control the organisation. The third aspect of formalisation refers to the requirements for holding a position. The organisation specifies what knowledge and skills the job holder must have and what norms he must exhibit. Training and indoctrination are the processes by which the job-related skills are learned and organisational norms and behaviour patterns are acquired.

1.9.2 Superstructure

The design of superstructure is concerned with the grouping of positions into units and determining how large each unit should be. Unit grouping can be viewed as a process of successive clustering; individual positions are grouped into clusters or units, these are, in turn, grouped into larger clusters or units until the entire organisation is contained in the final cluster (Mintzberg, 1979). Grouping is a method to coordinate work in the organisation since it establishes a system of common supervision among positions, requires positions and units to share common resources, creates common measures of performance, and encourages frequent communication among positions and creates a psychological link between them.

There are six bases to group positions into units and clusters: grouping by knowledge and skill, grouping by work processes and functions, grouping by time, grouping by output, grouping by client, and grouping by location. Furthermore, Mintzberg (1979) identified four basic criteria that organisations use to select the basis for grouping. First, work-flow interdependency that focuses on the relationships among specific operating tasks and sequential processes. Second, work-process interdependency that focuses on grouping to encourage high degrees of specialisation and functional interaction among groups. The third criterion for grouping is scale interdependency which requires adequate group size for efficiency. The fourth criterion, social interdependency, refers to the social relationships and personality of employees to facilitate mutual support and cooperation in each unit.

The second component in the design of superstructure is the size of organisation. Size has often been cited as one of the attributes having the greatest single influence on the extent to which organisations develop bureaucratic forms of structure. Various Aston group studies found the following relationships between size and structure: *"Larger organisations are more specialised, have more rules, more documentation, more extended hierarchies and a greater decentralisation of decision-making further down such hierarchies"*. According to Child (1973), the growth of the number of levels is mostly a result of vertical differentiation along with the growth of size and partly also a result of the limits of widening spans. Furthermore, one could think that as a result of the increasing number of levels, there should be some degree of decentralisation. Specialisation, too, has a positive relationship to decentralisation, since in a growing organisation authority to make decisions is delegated to specialists.

Peter Blau (1972, 1974) investigated the relationship between size and structure in several types of organisations and stated that: *"Organisational size rather than technology appears to exert the more significant influence on the division of labour and organisation of work".* Blau described two opposing forces created with increasing size. First, the organisation requires additional administrative personnel to coordinate the increasingly heterogeneous work activities. Second, the average size and homogeneity of the work units increase. The relationships between these two forces determine the net change in the managerial component. Blau and Schoenherr (1971) also explored the relationship between size and structural differentiation. They saw differentiation as having a horizontal dimension in terms of the number of division, and a vertical dimension in terms of the number of hierarchical levels. They found that although size had a positive relationship with structural differentiation, this was not linear since differentiation increased with size at a declining rate.

Lawrence and Lorsch (1967) pointed out that the more differentiated the structure, the more emphasis is placed on coordination. Thus, the larger organisations must use more elaborate coordination devices, such as a larger hierarchy to provide direct supervision, more behaviour formalisation to coordinate by standardisation of work processes, more sophisticated planning systems to coordinate by standardisation of outputs, and more liaison devices to coordinate by mutual adjustment.

1.9.3 Lateral Linkages

The design of lateral linkages are for the purpose of planning and controlling the system and creating liaison devices. As the problems between interacting units develop beyond the control of rules, procedures, or hierarchy, organisations increasingly use planning activities to improve intergroup performance. The purpose of a plan is to specify a desired output or to specify a standard, and the purpose of control is to assess whether or not that standard has been achieved and to regulate the performance and the overall results of a given unit.

When the number of interactions and volume of information between units or groups expand, it may become necessary to establish liaison devices to handle the new requirements. Liaison devices are developed to encourage contacts between individuals or units for reasons of mutual adjustments and to facilitate a better flow of information between the interacting units. For example, when a considerable amount of contact is necessary to coordinate the activities, a liaison position may be established to route the communication directly by more informal methods, by-passing the vertical channels (Mintzberg, 1979). Other examples of liaison devices are task forces and standing committees. When the complexities of interaction increase, the coordinating or decision-making capacity of the liaison position becomes overloaded. One solution to this problem is the formation of a temporary task force consisting of one or more representatives from each of the interacting units. Task forces do not have any formal authority and exist for a specific period of time as long as the problem of interaction remains.

1.9.4 Decision-Making System

The decision-making system, as the final design parameter, attempts to measure the exercise of authority by occupants of positions on the determination of particular issues. The literature suggests a number of ways of examining decision. The most common method is by determining the locus of the decision-making, that is, the location in the organisation at which decisions are normally taken. The difficulty about this method is that most important decisions are not usually taken by one person and ideas flow around the organisation until the final result emerges. Straightforward questions about the location can lead to contradictory answers if the people concerned are widely scattered in the organisation. Contemporary theories of decision-making stress the degree of participation as a more accurate reflection of exercise of authority, and the assumed multi-dimensional relationship between the vertical and horizontal decentralisation of structure. Vertical decentralisation involves the dispersal of power down the chain of authority and the lack of reliance on structural hierarchy for task control. Horizontal decentralisation refers to the extent to which non-managers control the decision-making process. When authority to make a decision remains within a particular function, this is called line authority. Horizontal decentralisation takes place when formal authority flows to non-managers or managers outside the line structure, such as support staff, engineers and other experts.

The use of decentralisation has its value to the degree that it assists the organisation in achieving the stated goals. The decision to decentralise is a complex process that involves a number of considerations. These include the following:

(1) Environmental factors - The impact of such environmental factors as diversity of the market, industrial relations, and variations in the economic trends are important influences on the decision to decentralise. As environmental problems become more complex and dispersed, organisations are expected to respond intelligently by decentralising the structures.

(2) Growth of the organisation - In managing complex organisations, it is nearly impossible to make all the decisions in one location or in one head.

This is especially true for organisations that are in the midst of significant growth phases. Since situations, problems and opportunities are developing at a rapid pace, it may become necessary for top management to delegate the decisions on certain issues to lower levels in the hierarchy.
(3) Cost of decentralisation - There is a reluctance on the part of many managers to delegate authority on a decision when the consequences may have a significant impact on the organisation. One view on this was expressed by Blau (1970): *"Managerial decisions are either significant, in which case they are not delegated, or delegated, in which case they are not significant"*.
(4) Locus of expertise - There are many instances when managers do not have the necessary knowledge and understanding to make a decision. Expertise may reside at some parallel or lower level in the organisation.
(5) Nature of the tasks - The hypothesis that the more routine the purposes to be fulfilled, the more centralised the organisation is well supported in many studies (Perrow, 1967). The nature of the tasks the organisation has to fulfil is found to influence the degree of centralisation and contrary pressures, like the need for motivation, are unlikely to be powerful under these circumstances.
(6) Ambiguity of purpose - Ambiguity of purpose within the organisation is identified as a pressure to centralisation, while uncertainty in the environment points in the opposite direction. Delegation is favoured when the unit finds itself in a fast changing and uncertain situation.

Centralisation and decentralisation are seen as opposites in one dimension. Between the extremes of centralised decisions which become rigidly bureaucratic, and autonomous decisions that can ultimately break up the organisation, there is scope for endless fluctuations. These fluctuations are not aimless and they can be tracked and predicted within identifiable limits. A hypothesis that stems from detailed observations (Tannenbaum, 1968) is that there is some point along the continuum to which a particular organisation will attempt to return. This is a similar idea to that of the compliance structure, where each type of organisation is seen as to have a distinctive relationship between the kind of power and the method of obtaining compliance, and there is a pressure to revert to that relationship. As one force becomes sufficiently powerful to push the organisation's balance towards one extreme or the other, powerful pressures move in to store the normal position.

1.10 REFERENCE TO RECENT RESEARCH

One of the most pervasive and central arguments in recent treatment of construction organisations focusses upon the analysis of intra-firms relations and the way in which the people involved in projects are organised. Many recent writers have suggested that the prime objective of construction management research should be the use of systems approach to study how various organisational parts and their interrelationships influence the effectiveness of the total process of project management. The following paragraphs present the contributions of some of these writers.

Nahapiet et al. (1982) called for the examination of simultaneous relationships among three clusters of variables identified as client attributes and requirements, project delivery processes, and environmental conditions, and the ways in which they together may influence project performance. Within the project delivery processes attention is drawn towards the basic need of creating an effective mechanism for bringing together a wide range of design, construction, and project specialists. Since these expertise come from several different organisations, a key decision for any client is the selection of a mechanism to manage the interorganisational relationships. Therefore, emphasis is placed on the project performance as a function of the management of highly interdependent activities across the interfaces of various groups rather than within each participating organisation. Nahapiet et al. concluded that the search for one best way to manage all projects is likely to be fruitless and highlighted the relevance of the contingency approach to suit a particular contractual arrangement to the requirements of the projects. Nahapiet states "The implication of this best-fit approach is that the trend towards diversification of project management approaches, both within and between organisations, is likely to continue. As a result, many individuals and organisations are likely to find themselves working in new patterns of relationship with other parties in the industry".

Winch (1988) identified three influential perspectives of socio-technical systems, differentiation and integration, and project management, and suggested that they were originally developed for the analysis of intra-firm relationships. Although research into these perspectives has encouraged their application to the management of construction projects, Winch argues that they have not been developed to consider a distinctive feature of temporary coalitions of firms with divergent economic and social interests. The central theme in socio-technical systems approach is that production organisations are both technical systems consisting of machinery and work processes, and social systems of personal and group interaction. These two are seen as independent variables whose features need to be jointly optimised to ensure high performance. However, there are two linked weaknesses with this approach. Firstly, the main focus is on the relationships within single organisation and all the team members under investigation are within a single hierarchy. Secondly, the perspective has difficulty understanding a context in which the members have differing economic interests.

The concepts of differentiation as the extent of the division of labour into various subsystems, and integration as the extent of coordination to achieve common tasks have found favour amongst many researchers. However, like the socio-technical systems approach, this perspective is developed for the examination of relationships within organisations, and cannot be transferred unadapted to construction projects. The main element of differentiation is between firms, and not departments and functions, which implies integrating across market relationships.

Project management as a distinctive managerial process is seen as a unifying agent across the functions of the organisation in the face of environmental and technological uncertainty. However, the fragmented nature of the construction industry means that functional differentiation is mainly between various organisations and the practice of project management only handles the differences between functional units within a single structure. Therefore Winch (1988) concludes that "all three perspectives share a weakness in that they do not incorporate any conceptual means for handling the predominance of the market governance of transactions between firms in construction, as opposed to the hierarchical governance of transactions within firms". Winch (1988) presented the transaction cost approach of Williamson (1981) as a starting point to develop an alternative approach which systematically looked both at relations within and between organisations. The key contention is that in addition to the costs of production, there are also costs of transaction between parties. "A transaction occurs across a technologically separable interface" (Williamson, 1981). WIlliamson argues that, where transaction costs are high, it is cheaper to transact within a hierarchy to provide the services, rather than rely upon market allocation of resources.

Morris (1972) saw the key priority for increasing the effectiveness of construction process to lie in the management of the dynamic interrelationships between various organisations found on a building project. The main area of difficulty is identified as the interdependence of design and construction, and hence the emphasis is placed on the investigation of the patterns of coordination and control at the design-construct interface in different conditions of uncertainty and complexity. Morris stated that where there is uncertainty and complexity it will be helpful to design semi-autonomous organisational subsystems and to concentrate one's managerial attention on their interrelationships. However, this can produce highly fragmented subsystems on each side of interface which would require more information processing for effective integration.

He proposed two ways of resolving this problem. The first involves the rearrangement of the ordering and positioning of subsystems and their interrelations. The second concerns the usage of various integrative methods depending upon the structural differentiation of the subsystems. Speed was identified as a critical factor in influencing coordination and control, since it affects the degree of overlap between design and construction, and the amount of reciprocal interdependence between functions. To handle the cross-over between the two stages, contractual arrangements encouraging early entrance of the contractor onto the project is suggested to be vital for adequate appraisal of design implications on project programme.

Tatum (1983) used prescriptive and descriptive models distilled from decision-making theory to analyse data regarding how managers design project organisations. His objective was to provide knowledge about the current practice to see whether it needs to be preserved or modified. The conclusions indicate frequent adaptation of past structures, particularly when urgent situations force quick decisions. When data regarding the situation are available and time allows, decision-making involves greater analysis and moves towards the contingency perspective.

Tatum recognised that varying situations such as progression through the project life cycle, performance difficulties, and changes in project goals demand a series of decisions regarding the appropriate configuration of structure. Therefore, relying heavily on the ideas presented by James Thompson (1967), Tatum proposed a framework as a starting point for the systematic decision-making to custom design an organisation according to specific project requirements. The proposed structuring process contains eight steps: define project objectives and set priorities, define line management organisation, provide appropriate means for coordinative tasks, decide level of staffing and size of each unit, design staff groups, add planning and monitoring systems, locate decision-making and delegate authority, and finally define requirements for positions. Although the contractor's organisation is considered as the unit of analysis, Tatum also refers to the importance of external influences and the need to locate the staff groups adjacent to the line segments for direct interaction and to buffer the operating core from the environmental disturbances.

Bennett et al (1980) in relating current organisational theory to the construction industry emphasized the importance of the industry's distinctive feature of fragmentation and temporary coalition of specialists firms with sometimes divergent economic and social interests. In response to the requirement of creating a unique organisation composed of individuals and groups drawn from a selection of various firms, the stated objectives are better achieved through an appropriate choice of contractual arrangements and project delivery systems. Bennett expands upon this macroscopic view to include in his theoretical premise that the choice of organisation should be based on the analysis of the construction process which is considered as a link between the project organisation and the tasks performed. A simulation model is introduced to measure the effect of variations in size, production technology and predictability of the task, as major determinants of process, on the changes that can occur on cost and duration of site activities.

1.11 RESEARCH APPROACH AND OBJECTIVES

The construction industry is one of fragmentation of specialised work processes into literally thousands of pieces that are well orchestrated for the achievement of project objectives. These processes or operations require labour, material and machine resources in various proportions to accomplish a productive activity, and an effective organisation to combine and arrange the efforts of a large number of people. Similar to work processes, that depending on the technology leads to variations in the manner of task accomplishment, the project life-cycle is also a process with definite and often discrete stages, illustrated in Figure 1.3, which can broadly be defined as predesign, design, and construction. The latter and the most visible stage is the erection, maintenance and repair of buildings and other immobile structures. It necessitates local and on-site production over a wide geographical area and is for the most part made especially to the requirements of each individual client. This, together with the shift of emphasis in project programmes, creates a challenging task in coordinating the work processes and organising the primary functions of personnel at various levels of management.

The objectives of the research, within the above context, were to explore the interactive effects of environment and technology on the essential parameters and components of organisation and to identify the dominant decision processes in the task of structuring. In order to structure the study of the phenomena in question, it was necessary to adopt an appropriate methodology and utilise a design strategy to direct the research efforts. Kahn and Mann (1969) stated: *"If we grant the importance of doing social research in functioning organisations, we immediately face the problem of how such studies are to be conducted"*. Rowan (1976) argued

FIGURE 1.3

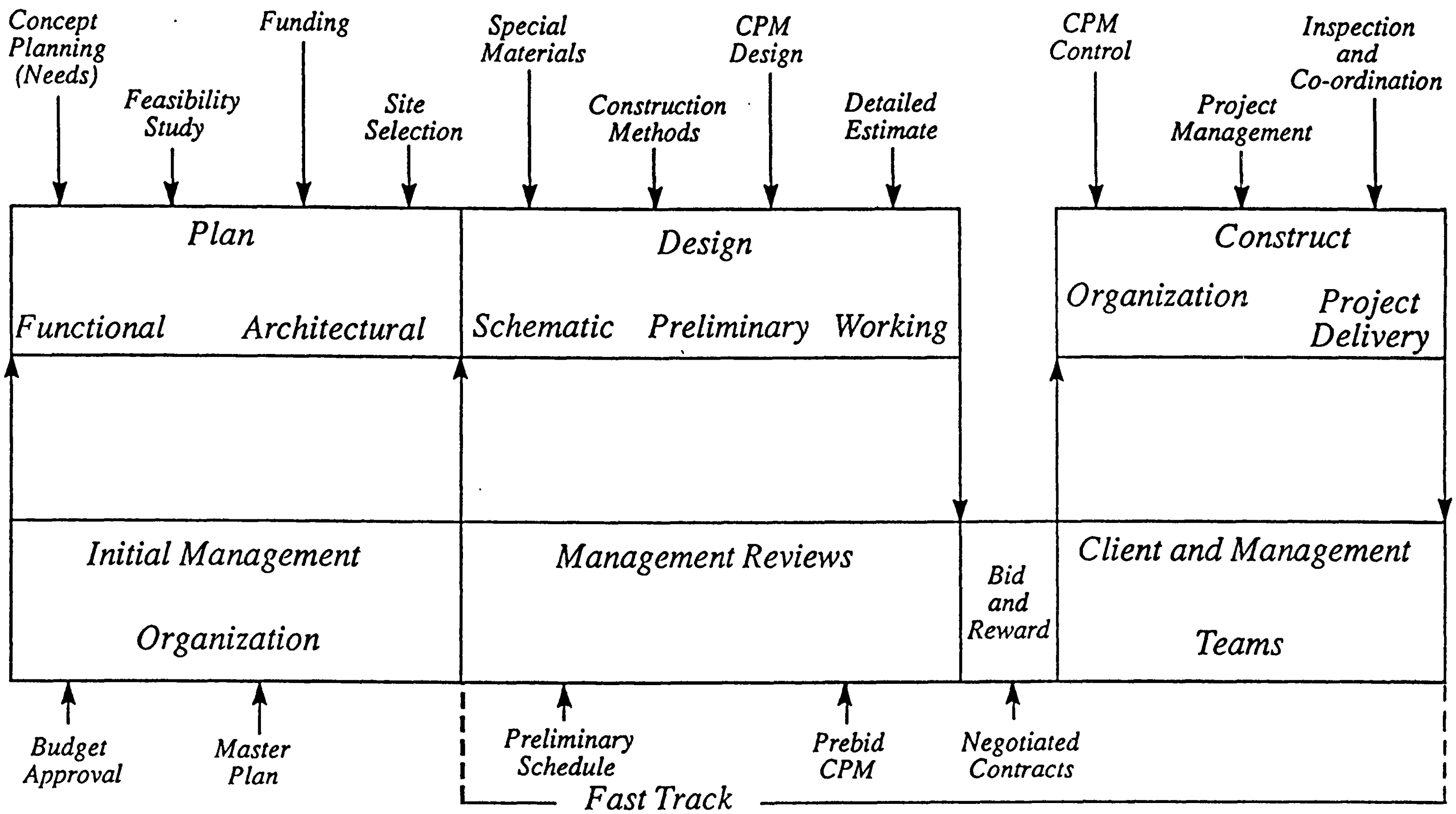


FIGURE 1.3: Plan-design construct project cycle showing systems imputs

that there are a wide range of research methods depending on the journey being planned. Diesing (1972) defined methodology as being a whole series of steps that the scientist or the research team follows in the process of making a contribution to the field of knowledge. In this study, the approach followed the traditional research strategy using theory to generate precise hypotheses about the empirical relationships when a contingency process is in operation, and tested against the established forces of habit and specific configurations of structure with the aim of validating or invalidating the theory.

The review of organisational research has revealed a number of fundamental issues related to the applicability of traditional theories and approaches to the understanding of organisations. Most modes of exploration and research in the literature are derived largely from sources of rational and behavioural theories. Such a view of organisation which emphasises both the human action and the objective structure, implies the importance of processes through which particular patterns of behaviour are established and the interactions through which variety of structures are produced. In Weick's (1969) opinion: *"An organisation can be understood only in terms of the processes that are underway, or its organising activities"*. Therefore, appropriate to the development of an understanding about how organisations are perceived and structured, from the rational and behavioural theories five models with differing assumptions and biases were constructed to represent various decision-making processes and to examine and identify the one that dominated the task of structuring.

A wide range of data was collected to provide an assessment concerning the dimensions of environment and technology and information about the design parameters, and to provide an account of the projects particularly the development of events throughout the contract from commencement to completion. The collection of data required site visits and interviews which were characteristically semi-non-directive. The participants were not required to give responses to questions on matters they might never have considered or have no clear opinion, and it was hoped that data would emerge about issues truly important to both the participants and the interviewer. However, to offer some direction and to occasionally promote further discussions around the issues, a short list of specific questions was prepared (Appendix B). There were also interjections at various points during the participant's accounts with the aim of enriching the data collected by specific examples to support the general statements. To reduce the ambiguity and to fully acquaint the participants about the nature of the research, the objectives and the rational behind the approach were addressed in the initial discussions. Such details helped to minimise the fear and anxiety associated with participation in the research. Furthermore, the anonymity of the respondents and the confidentiality of the responses were stressed.

Chapter Two

2.1 INTRODUCTION

In the course of the research detailed studies are made of a sample of 18 building and civil engineering projects, reflecting a wide range of performance as well as different methods of procurement arrangements and organisational structures that currently predominate in the industry. The studies cover case history of each project, the contractual and administrative aspects, the views on site teams and technical considerations, and are based on interviews with one of the principal parties to the contract and supplemented by information extracted from project documents, drawings and programmes, and site minutes.

The chapters are presented in the following order. First, a brief summary of the project purpose and scope is provided in Table 2.1. For a more comprehensive description of each project, they are reproduced with respective details in the Appendix A. The basic mechanisms for contract delivery system and the contractual arrangements are then discussed. These mechanisms determine the interorganisational relationships between various parties and define the role and responsibilities of the main contractors and the conditions under which they apply. Second, the environmental and technological conditions under which the organisations exist and operate are identified and from the assumed structural implications six hypotheses are derived. The validity of hypotheses are examined by detecting any inconsistencies between the formal structure of site organisations, represented by the design parameters, and the implied structural characteristics. In the final chapter, models of strategic decision-making are constructed by extracting relevant propositions from the rational and behavioural theories. The objective is to determine the dominant decision processes in organisational structuring by testing the underlying assumptions and biases of each proposition against the experience and opinion of contract managers who participate in such processes.

Summary - Project Scope and Purpose, Table 2.1

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.1	23.5	160	South-East	Offices with underground car park spaces and ground floor shop units.	33	NA	Competitive tender based on full bills of quantity, JCT80.	A division of a major international contracting company, specialising in building construction including leisure, commercial and industrial buildings and refurbishment.
C.2	2.5	46.7	West-Midlands	Refurbishment and extension of an existing two-storey office building.	9	9	Competitive tender, design-construct for the extension and management contracting for the refurbishment.	A division of a group of companies offering nationwide building and civil engineering services.
C.3	3.1	132	South-West	Construction of a new distribution depot and warehouse including 1.5% office area.	7.5	8	Competitive tender based on full bills of quantity, JCT80.	A West Country division of a major international contracting company providing a total building and civil engineering service.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.4	24	300	South-Wales	A new county hall to accommodate the offices of the county council and provide other facilities including on-site parking for up to 100 cars.	29	32	Competitive tender, management contracting.	A division of a major group of companies offering services in building construction and civil engineering projects.
C.5	1.3	45	South-East	Refurbishment and partly rebuilding of an office building.	12	18	Competitive tender based on full bills of quantity, JCT80.	A division of a major group of companies offering services in building construction mainly in the South-East.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.6	5.363	NA	South-west	A 3 km long relief road to bypass and divert traffic from a town centre.	16	22	Competitive tender, ICE 5th.	A South-West division of a major international civil engineering contractor.
C.7	1.7	20	South-West	Refurbishment of a superstore including the extension of the sales area, a new training room and a bakery.	8	8.5	Competitive tender, JCT80.	An autonomous division of a group of companies carrying out building and civil engineering works in the South-West counties.
C.8	7	NA	South-East	Construction of a new prison to accommodate 400 single and double cells on an existing prison estate.	30	NA	Competitive tender, based on full bills of quantity, JCT80.	Southern division of a construction group specialising in building developments and refurbishments for both private and public sector.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.9	22	NA	South-East	Construction of a new prison consisting of 11 two-storey high buildings providing in total 26,000 square metres of floor area.	30	30	Competitive tender, management contracting.	A major management contracting firm participating in large building developments and housing projects.
C.10	6	30	South-East	Construction of a seven-storey office building including two underground floors.	20	22	Competitve tender, based on full bills of quantity, JCT80.	A division of a large group of companies carrying out building construction and housing developments in England and Wales.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.11	2	19.3	South-East	Conversion of a seven-storey listed building into a block of luxury flats, requiring the demolition of many parts.	18	NA	Negotiated contract based of full bills of quantities.	Southern division of a group of companies providing services for the private and public sectors in area of building construction, refurbishment and maintenance.
C.12	24	300	South-East	Construction of a shopping precinct within the boundaries of a residential development, including outdoor parking spaces.	20	NA	Negotiated design and building contract.	A division of an international group of companies handling building contracts and major shopping developments.
C.13	12.1	NA	North-Wales	Improving 43 km of road system into a dual two-lane carriage-way, including 1/2 km of tunnel	24	30	Competitive tender, ICE 5th.	A civil engineering division of a large international group of companies carrying out contracts in the West counties and Wales.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.14	7.2	NA	South-East	Construction of additional taxiways and turnoffs to provide access to terminal's aircraft stands, including the installation of a new drainage system.	16	16	Competitive tender, ICE 5th.	South-East regional office of a UK based international civil engineering contractor.
C.15	30.6	NA	South-West	Structural Work for the maintenance and strengthening of two bridges with the length of 9817 feet, as part of a permanent river crossing.	NA	24	Competitive tender, ICE 5th.	Mechanical and industrial engineering and construction division of a large group of companies with UK and overseas activities.
C.16	270	NA	South-East	Initial phase of the new British Library building as a centralised national repository for up to 25 million documents	42	NA	Selective tender for construction management contract.	Southern division of a management contracting firm belonging to an international contracting group.

Summary - Project Scope and Purpose, Table 2.1 (cont)

Case Study No.	Contract Value £1,000,000s	Commercial Space Ft^2 (000s)	Location	Description	Months: Planned Construction	Months: Actual Construction	Contracting Method	Contractor
C.17	150	175	South-East	Initial phase of a large office block development consisting of four eight-storey office buildings providing modern offices and dealing rooms for international finance houses.	36	36	Negotiated contract for construction management services and fast-track management techniques.	A major management contracting firm participating in large building developments and housing projects.
C.18	15	NA	Midlands	Installation of a new plant within an existing pharmaceutical factory compound to increase penicillin production capacity with a modified fermentation process.	24	24	Competitive tender for integrated design and management contracting service.	An international process engineering contractor and consultant offering a complete project management and engineering services to the process industries.

Case Study 1

Project Delivery System

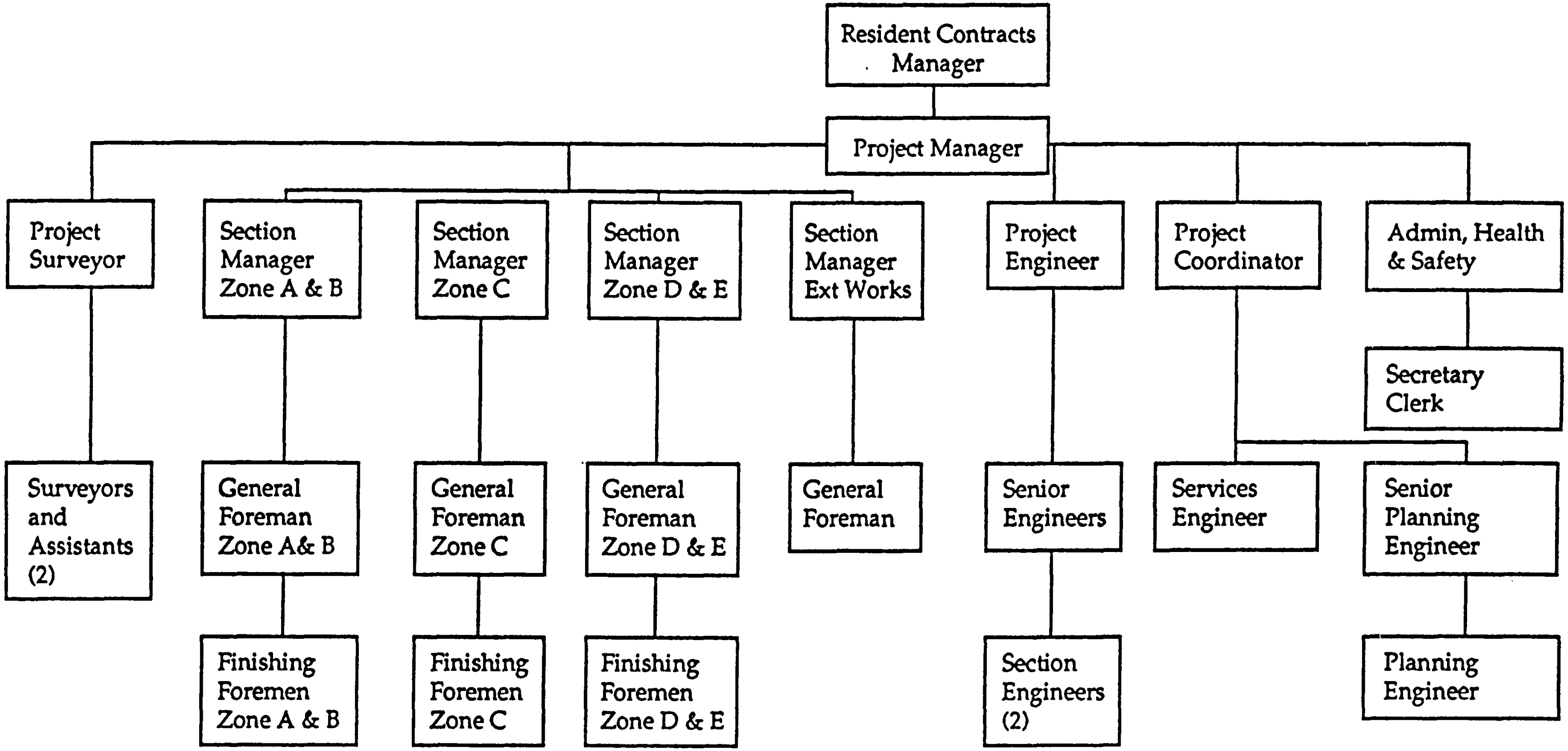
A total of 4 contractors were invited to compete for the tender based on full bills of quantities, with JCT80 as the form of contract. The list of contractors invited to bid was based on the previous experience of the client with the work of those contractors and his familiarity with their organisations.

The client selected an architect to become the design team leader and, after pre-construction phase, the project manager representing the client. The architect was responsible not only for the overall design of the project and for the supervision of the contract phase, but also for co-ordination of the other designers and design inputs of subcontractors. The quantity surveyor was responsible for the preparation of bills of quantities, making monthly valuations and preparation of final accounts. The architect, though, did not reside on site, but had access to the main contractor's site organisation mainly through the resident contracts manager and the project manager, and made frequent formal and informal visits. The contracts manager is usually stationed at the head-office, but it is the policy of the company that for projects larger than £20 million the manager becomes resident on site. The resident contracts manager had no experience in working in that part of the country, but that lack of experience did not create any problem, since the site location was very favourable being near a town centre and a motorway. He has been with the company for more than 10 years and is well indoctrinated with the norms and required behavioural patterns in his company. He is usually given more than one contract to manage and in this case he had two other contracts all located within 3 miles radius and with easy access for frequent visiting. Although the contracts manager was closely involved in controlling the contract and had overall responsibility to run the job and meet the targets, he visited the head-office at least once a week to report to the area director and discuss the progress and problems of the project. The area director decided to keep a close eye on the project, since this particular client is involved in large office developments and could become a regular client for future developments.

The main contractor's site organisation employed 27 site staffs and 25 direct labourers and its structure was not designed from scratch and was identical to other previous structures. It had an important feature and that was the work on site was divided into six different zones and then grouped into four sections, each headed by a section manager. The project, due to its design, required the services of many specialists during both the design and building phases, and in general as the project got more complex, the main contractor's reliance on subcontractors to do the work increased. In this case there were 65 different subcontractors handling approximately 75% of the work. The principal subcontractors were: the general mechanical contractor for mechanical works of main office areas, the general electrical contractor for electrical works of the main office areas, the contractor for supplying and installing the lifts, the contractor for cladding including curtain walling and glazing, installation of raised floors in main office areas, and installation of suspended ceilings. During the finishing phase the main contractor was responsible for the demands of the occupier through the client. At peak there were 175 operatives and labourers working for the subcontractors on site.

The resident contracts manager and the project manager were both appointed to the project by the area director and they respectively had the responsibility of taking corrective actions during the course of the contract to bring the job back onto programme and ensure timely completion, and monitor and co-ordinate the activities of section managers. The site organisational chart, indicating the positions and formal channels of communication in the management structure, is given in Figure 2.1. The structure of organisation did not change during the construction but the number of employees on site, the type of trade specialists, and the work load of each section changed according to the programme.

Site Organisation Chart, Figure 2.1



Case Study 2

Project Delivery System

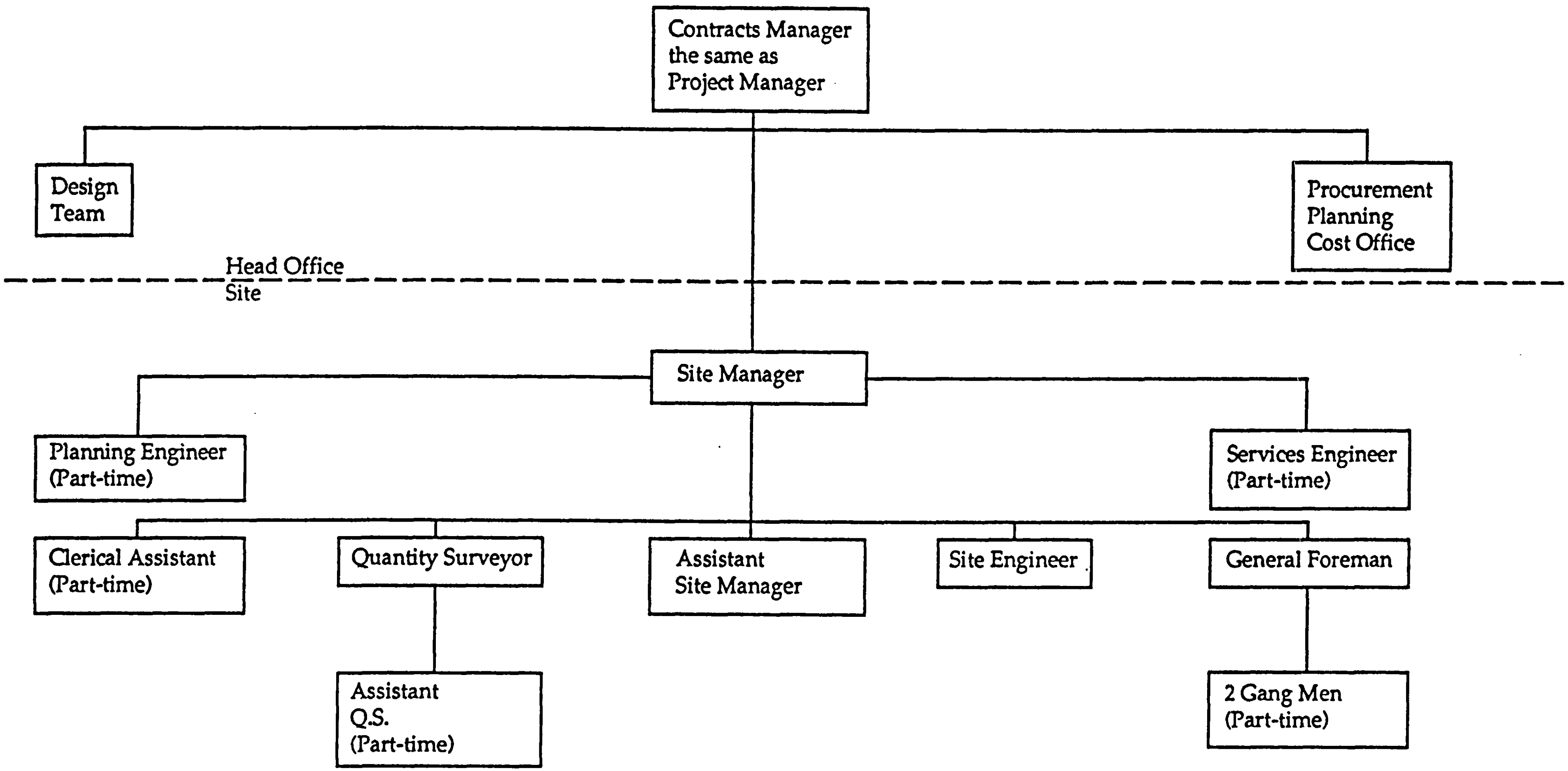
The original building was constructed by the same contractor who obtained the contract, therefore although there were 3 other competitors participating in the tender, the competition was thought to be not very severe due to the previous successful working relationship between the contractor and the client. The contractor was invited to make recommendations on three available contracting routes to be adopted by the client for the completion of the project. The design-construct and management contracting option were selected considering the strengths and weaknesses of the arrangement. The contract route provided the fastest on site contract commencement since construction work began before completion of design work and variations were accommodated more effectively in terms of programme schedule. The contract arrangement was more receptive to programme changes as required by the client or the situation on the site.

The appointment of the contractor at an early stage allowed for early and integrated procurement, planning and site preparation and generally widened the range of construction expertise available to the client. The contractor did not undertake any of the physical work on site, except cleaning and removing waste and bringing materials to the site, and let the construction to subcontractors in a number of packages mostly by competition and often on approximate bills. They brought together the services of small local contractors who individually would not have the resources to handle the whole project. For the management contracting portion of the work the contractor was employed as a consultant by the client to provide advice on the practical methods of construction, cost effective design, cost and quality control, and safety procedures. The client would not participate on selection of the subcontractors, since they were placed under the name of the contractor, but the client had to agree with their accounts for each element of the work. The contract arrangement caused some predictable problems. For example, although the approved cost plan was available, the overall tendered cost was not available when work commenced. There were split responsibilities between design and workmanship on all but the "shell only" works. There were no commercial incentives to obtain the most effective solution to problems, although discussions were conducted with the main contractor to overcome this obstacle. A clause was included in the contract for a guarantee with maximum price where savings were shared with the client, but the excesses had to be carried by the contractor if the cost went over the top.

The client had a project team of 5 people headed by a project manager stationed on site and occupying the ground floor plant offices. They were employed permanently to manage and supervise the building projects undertaken by the client. Therefore, in controlling the project the contractor had a partner who was present at all design team and site meetings. Regular internal meetings ensured that the client's project team were kept fully informed of the detail to enable backup cover when relevant. For the design-construct extension, an architect was employed for checking and advising on detail design and construction and monitoring contractors progress. In addition to design team meetings, he would visit the site as necessary to ensure the client's interests were served. The refurbishment project ran in parallel to the extension and the contractor provided a full architectural service for this element utilising the same architect. The scope of the service was in accordance with RIBA Appointments of Architects 1985, including the interior design aspects of all associated elements covering furniture, fixtures and artwork. The architect was also responsible for controlling day to day contractual contacts and liaisons with the client's representatives. The architect participated in design team meetings held on a two-weekly basis from appointment through to start on site and thereafter as necessary. Their purpose was to continually monitor progress, decision-making and costs, between all parties and establish key dates throughout contract period. In addition to design team meetings, the architect would visit the site once a week to coincide with contractors site meetings.

The site organisation was headed by the contracts manager at the head office, who is very experienced and has been with the Company for 19 years. The contracts manager took up the role of the project manager and his responsibilities began prior to the award of the contract assisting in negotiations and providing help to the estimators, until the settlement of the final account. On the building site, he ensured that the site organisation had correct resources to carry out the job, and maintained his co-ordinating function from the head office. The contractor's organisation employed 11 site staff of which 6 were part-time who joined the operation after the completion of the first package, the extension, and remained with the organisation throughout the refurbishment work. At peak there were 60 operatives and labourers present on the site working for various subcontractors. Most of the work, approximately 95%, was done by the 25 subcontractors and trade specialists and only the cleaning, removing waste, bringing materials to the site and other small jobs were handled by the contractor. The structure of the organisation was identical to the previous structure used on a similar project and did not alter throughout the contract except for the need to increase the number of site staff after the completion of the "shell only" extension wing. The organisational chart is presented in Figure 2.2.

Site Organisation Chart, Figure 2.2



Case Study 3

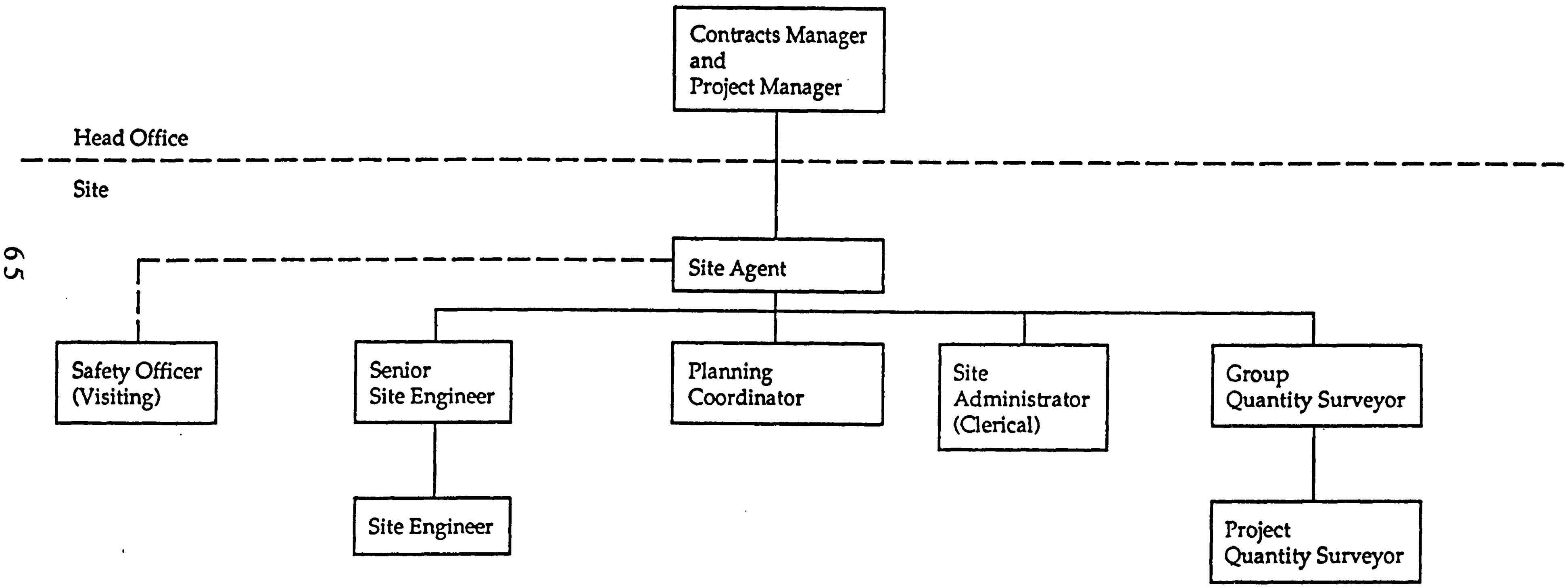
Project Delivery System

A list of seven potential contractors was prepared based on their involvement in the construction market of that region and invited to bid competitively according to the contract conditions of JCT80. The client decided to follow the traditional method of appointing a consultant designer, who was an architect, as his principal representative to prepare a brief, co-ordinate the contributions of other specialists, select the contractor, and to provide site supervision. After establishing the brief and developing the scheme in detail, the architect took on the responsibility of managing the project on behalf of the client during the construction phase. The involvement of the main contractor on design issues was limited, since the consultants prior to construction commencement had produced the layout and the design. Only some portion of the design remained to be detailed by the relevant subcontractors to be submitted for approval. The architect had access to the site through the site agent and participated in the monthly meetings to convey the client's requirements and monitor the progress.

The contracts manager had recently joined the company and had been employed there for 15 months during which he had managed 3 contracts including the distribution centre. According to the contracts manager his main responsibility was to make sure that the building was completed according to the client's conditions and specification and to bring about a harmonious and efficient interaction between the organisational resources and to influence events as the project proceeded from sanction to commissioning. The contracts manager, who had also taken up the role of the project manager, was stationed at the head office and was in day-to-day contact with the site agent. Although the contracts manager had recognised that there were many organisational alternatives open for implementation, in order to avoid confusion he decided to use three identical structures for the 3 similar projects that he was managing. However, he stated that in organising the site activities he usually considers the situational variations and the organisational requirements, and adopts structures by reviewing the alternatives. The site organisation was headed by the site agent, who was mainly responsible for co-ordinating and supervising the contributions of the subcontractors, and contained seven line and support staff including 2 site engineers, 1 planning co-ordinator, 1 site administrator, and 2 quantity surveyors, and 1 visiting safety officer. There were in total 25 subcontractors and trade specialists of whom one was nominated, and they were appointed to complete approximately 95% of the work by contract value. Only very minor activities were handled by the main contractor.

The structure of the organisation remained unchanged throughout the project, although the workload and consequently the type and number of operatives varied according to the programme. The site organisational chart is depicted in Figure 2.3.

Site Organisation Chart, Figure 2.3



Case Study 4

Project Delivery System

The client found the method of management contracting an attractive option to handle this public sector project with the belief that the requirements for public accountability can easily be met in respect to commercial decisions. The contract was put to competitive tender and 5 management contractors with strong local presence were invited to bid for the contract. The client wanted the management contractor to work alongside his professional consultants and become his joint project manager. The underlying philosophy of this approach was to allow the contractor to become part of the client's team in partnership with the members of the design team to provide the total management function.

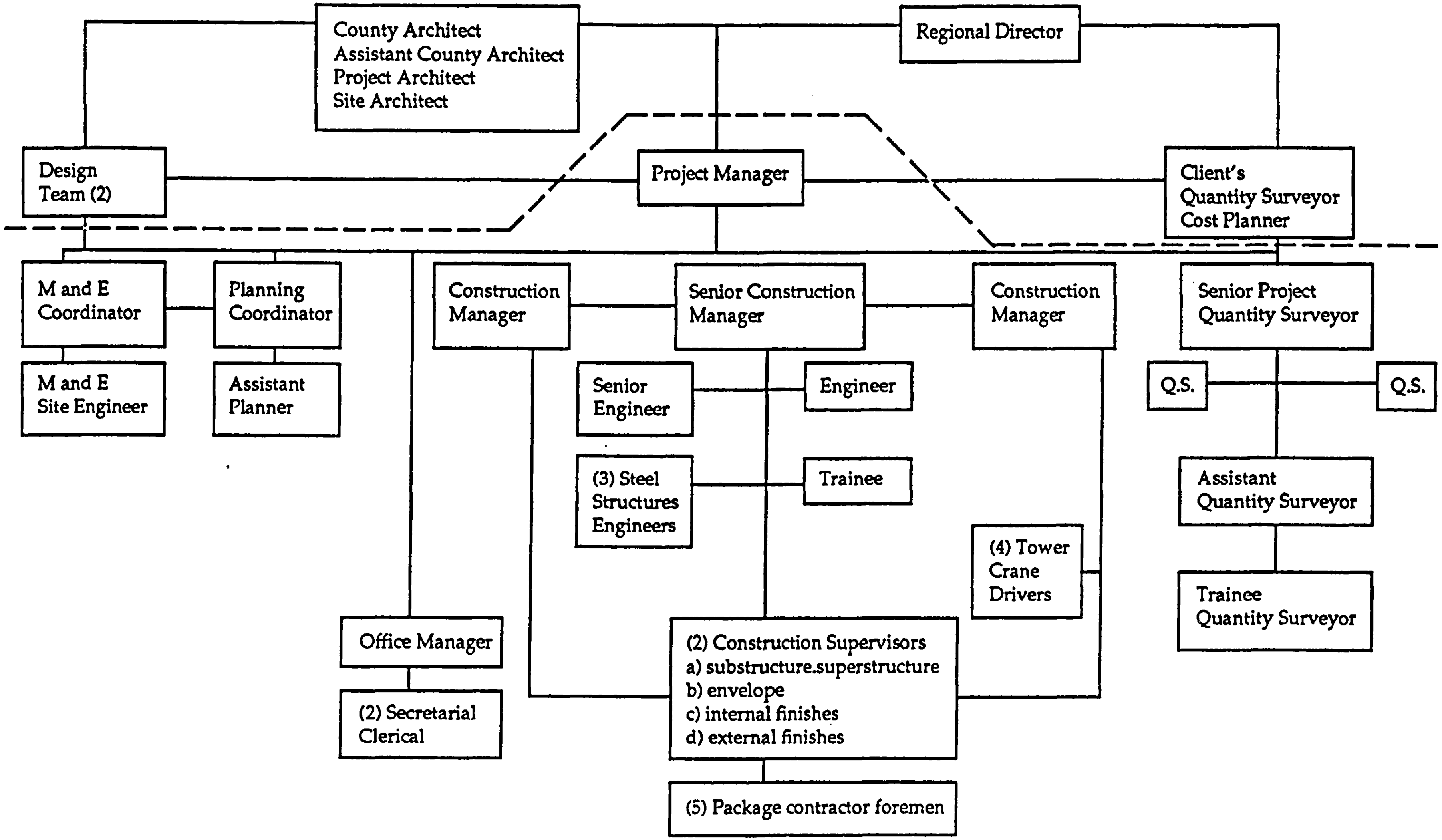
The management contractor did not carry out any of the construction and each element of the work was let out on a competitive basis to a number of specialist subcontractors. The management contractor was responsible for the setting up of the site establishment and general back-up services, however most of the subcontractors had to provide their own site accommodation and plant. The management contractor fees and preliminaries were more or less the same as the normal levels of preliminaries found on lump-sum contracts. In order to prevent specialist subcontractors, especially for large packages, to apply their own levels of preliminaries resulting in a duplication of site resources, special attention was paid to matters relating to procurement and handling of resources.

To meet the client's specific requirements and to make decisions concerning matters outside the domains of the site organisation, the regional director and the county architect led the client's head-office project team. The project team consisted of 10 people and apart from the regional director and the county architect it included the assistant county architect, the project architect and the site architect, two engineers as the client's design team, the client's quantity surveyor and cost planner, and the director of environment. The contract manager was appointed by the regional director to head the site organisation with total and overall control of the project including selection and management of subcontractors, and to be the client's joint representative on site. The site organisation was structured with little reference to the previous site organisations, but followed the general arrangements in managing the design and construction. Throughout the life of the project the structure remained unchanged, but there were fluctuations in terms of the type of work done and the concentration of men and materials on site at various stages of the programmes. However, there were some changes in terms of personnel. The project manager was removed from his duties on other contracts and was brought to the project six months after the commencement to replace the existing project manager. The senior construction manager was retired and was replaced by the construction manager in charge of the internal finishes and mechanical and electrical services. The mechanical and electrical co-ordinator was changed three times, and twelve months into the programme two other positions were introduced into the organisation. These were the mechanical and electrical site engineer and three steel structures engineers.

The management contractor assumed total responsibility for the contract performance of all the participants including partial responsibility for the co-ordination of the design as well as the duties associated with the project manager's role. The county architect was effectively in control of the client's design team and also carried out functions of a project manager. The project and the site architects were frequently in contact with the project manager on site and participated in site meetings to share project information and monitor progress.

The site organisation chart indicating the project management structure is given in Figure 2.4.

Site Organisation Chart, Figure 2.4



Case Study 5

Project Delivery System

A list of 6 contractors were invited for competitive tendering based on full bill of quantities drawn up by the client's quantity surveyor. The form of contract was JCT80, the standard form which provides penalties in the form of liquidated damages, but not bonuses for early completion. The contract was tendered in two stages. The first stage was submitting the price for the preliminary works, and the second stage was submitting a series of prices for each package of work as the design was completed. Before the contractor was selected to tender, enquiries were not made about the site personnel who would be handling the job, however, the track record of the firm, their experience with the type of building, and their experience in the geographical area were investigated.

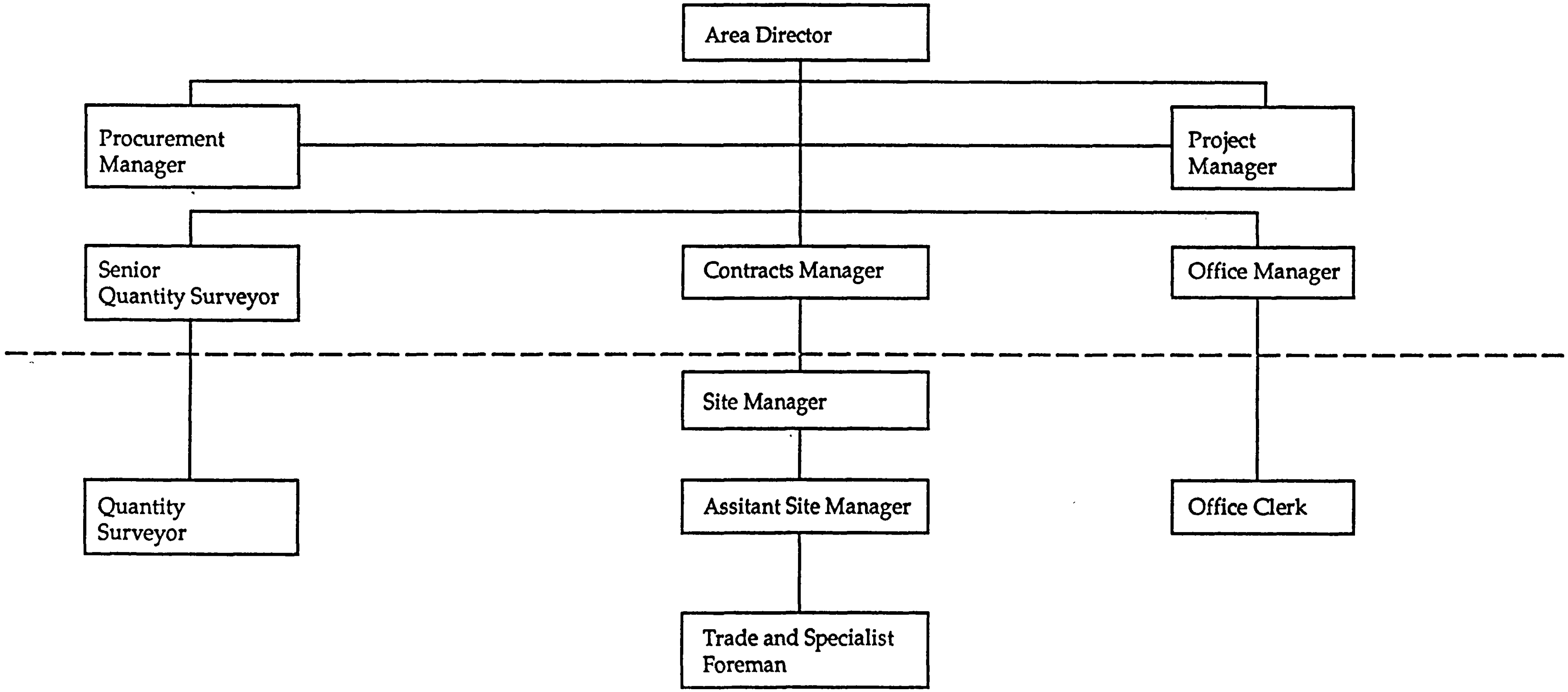
The contractor stated that the quality of performance could have been influenced by management continuity between pre-construction and construction phase, which in this case did not exist, and the establishment of effective site management with an adequate back up team and resources for the site manager within the contractor's own organisation. The lack of experience on behalf of the site manager who was not successful in co-ordinating the work of subcontractors and the failure of the main contractor in finding a replacement did not help in securing a speedy construction.

The peak total size of the construction team on site, including the main contractor's staff and the subcontractors, was 35 people. The main contractor's organisation constituted a site manager, an assistant site manager, a trade and specialist foreman, a quantity surveyor and an office clerk. The site manager was given authority to make decisions himself as far as possible, and where reference back to the architect was unavoidable, a mechanism was established for him to have access to the architect. The project was headed by the contracts manager who was stationed at the head-office and had the responsibility of reporting to the area director, selecting the site staff, liaison between the client's team and the site, and taking corrective actions where adverse trends were apparent. The site manager was responsible for reporting to the contract's manager, and also managing and co-ordinating the activities of the subcontractors. This became an important aspect of his work, since it was a deliberate and properly organised management strategy of the company to rely on subcontractors to do 100 per cent of the job.

The client chose the traditional method of appointing a consultant designer, who was an architect, as the principal protagonist in the project to design the building, co-ordinate the work of structural and services engineers, and supervise construction on site. The architect was not stationed on site, but made fortnightly visits and was in direct communication with the contracts manager and accessible to the site manager.

The site organisation chart, indicating the positions and formal channels of communication among the site staff, is given in Figure 2.5. The structure of organisation did not change during the construction, but the number of trade specialists and the emphasis on their activities changed according to the programme.

Site Organisation Chart, Figure 2.5



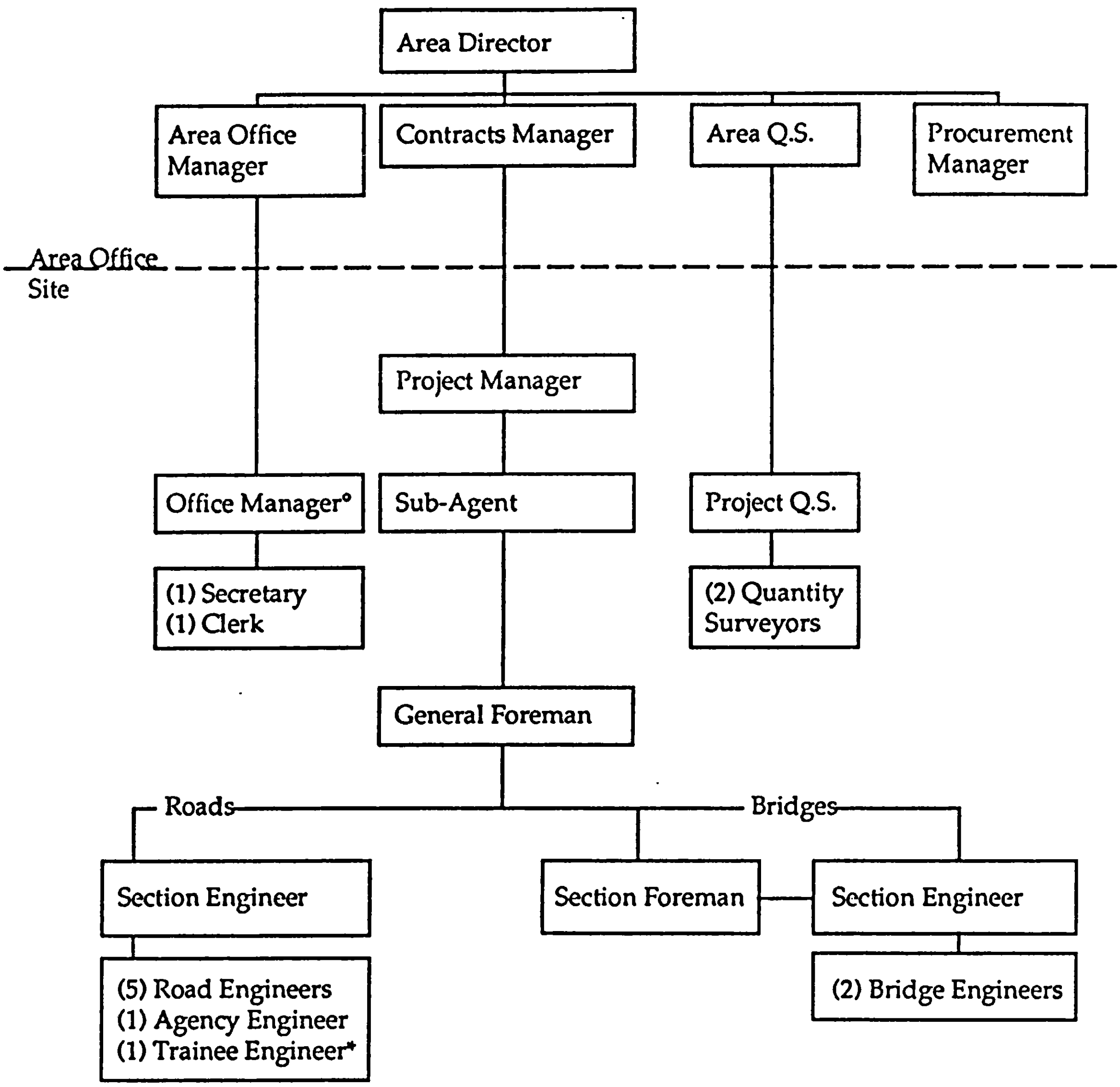
Case Study 6

Project Delivery System

The contract was tendered for in a competitive way with 5 other firms all specialising in civil engineering projects. The form of contract was ICE (5th Edition) fixed price with valuation and payment based on monthly basis. The total number of direct employees at the area office is 75 people including marketing, estimating, procurement, quantity surveying and clerical staffs, of which some were allocated to the relief road site. The total number of staff assigned to this contract were 19 with site engineers being supplemented by the use of one agency engineer. In addition to the site staff there were 17 directly employed labourers, who started work seven months after the commencement of contract, and who included two gangers, seven labourers, three machine operators and five chainboys.

The client had under his employment the county council engineers who provided the outlay design and on site representation through resident engineers staff. The main contractor's organisation consisted of an area contract staff stationed at the head office (or area office) and site staff headed by a project manager whose work was monitored by the contracts manager in the area office. The site organisation chart, indicating the positions and formal channels of communication among the site staff is given in Figure 2.6. One of the important aspects of the organisational chart is that the contractor separated the field activities into two sections, one for the construction of bridges and another for the construction of the road and two roundabouts, and each section was headed by an engineer whose work was controlled by the line managers.

Site Organisation Chart, Figure 2.6



* Two trainee engineers, one for three months vacation placement and another for six months sandwich placement.

° Part time.

Case Study 7

Project Delivery System

A short list of 5 local contractors based on their records and capability to bring the project to a successful conclusion were invited to tender and compete for the contract. The contract form was JCT 80.

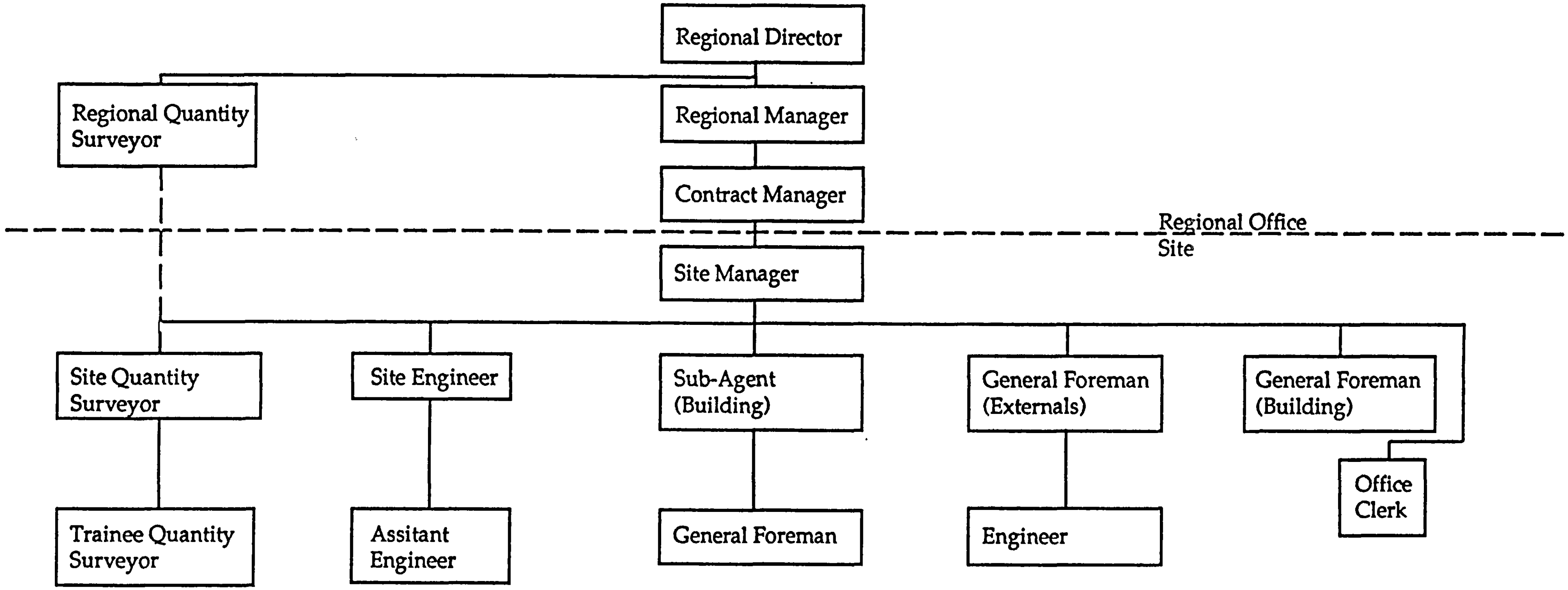
In conventional contracts one of the causes of difficulty is the lack of sufficient or precise information at the time of the tender. In this case the client did not want to delay tendering until the work was better defined and encouraged a tight programme. The main contractor received extra payment to start the job early allowing only 3 days of preparation before commencement.

The client was represented by an architect who also headed the design team and whose responsibilities included the timely production of information when needed and that the designs and specifications were compatible with the sanctioned brief and budget. The client appointed a resident manager to supervise the site activities and report directly to the visiting architect. For the finishings and fittings the resident manager was replaced by a project manager who was an employee of the client in the superstore. The client's representatives resident on the site were in direct contact with the architect and the site manager and were requested to refrain from interfering with the work by contacting other members of the site team. However, the combined efforts of the site manager and the site quantity surveyor were needed to create a buffer to limit the influence of the client in the site organisation. Also, arrangements were made so that in case of any need for clarification of design ambiguities the site staff could directly communicate with the assistant architect.

The main contractor's site organisation was headed by the site manager who had been with the company for 18 months. His main responsibilities were to co-ordinate all the line supervisors, to co-ordinate the input of all the subcontractors, and act as a liaison between the involved parties. The site manager, just before the start of the 20th week, was promoted to contract manager and was moved to the regional office but continued to visit the site and supervise the work in his new capacity. The sub-agent became the site manager and took on the new responsibilities for the final stage of the project. The organisational structure was based on the structure of previous site organisations and the site manager did not have any specific experience to indicate that one structure performs better than others. The regional office was headed by the regional director who was informed about the progress of the project through the regional manager and the regional quantity surveyor. For the first section of the contract, the regional manager had the responsibility for contract administration, although the usual practice is to have a contract manager in the regional office to administer the contract and lead the project. This responsibility was transferred to the contract manager as soon as the site manager occupied the position at the start of the second section of the contract. During the last 12 weeks of the contract there was a reduction in the workload and a change of emphasis towards the refurbishment of the existing offices and the restaurant and building a new cash office. Therefore, only the site manager (who previously was the sub-agent), the site quantity surveyor and the assistant engineer remained in the site organisation. The general foreman for external works and the general foreman for the building works resigned, but were not replaced since their work had been completed. The contract manager expressed the opinion that in a next similar project allocation of a supervisor to the ancillary areas would be recommendable, since this shortage was realised later in the project and the problem was resolved by the appointment of the general foreman for the building works who was not allowed for in the tender price.

There were 15 main subcontractors and 20 minor subcontractors who were selected by the contract manager to do 100 per cent of the work. However, the main contractor had to take over a portion of the contract which was worth £250,000 from a subcontractor who was not meeting the targets. At peak there were 32 people employed on the site including the 11 staff belonging to the site organisation. The organisational chart outlining the formal management structure of the site is given in Figure 2.7.

Site Organisation Chart, Figure 2.7



Case Study 8

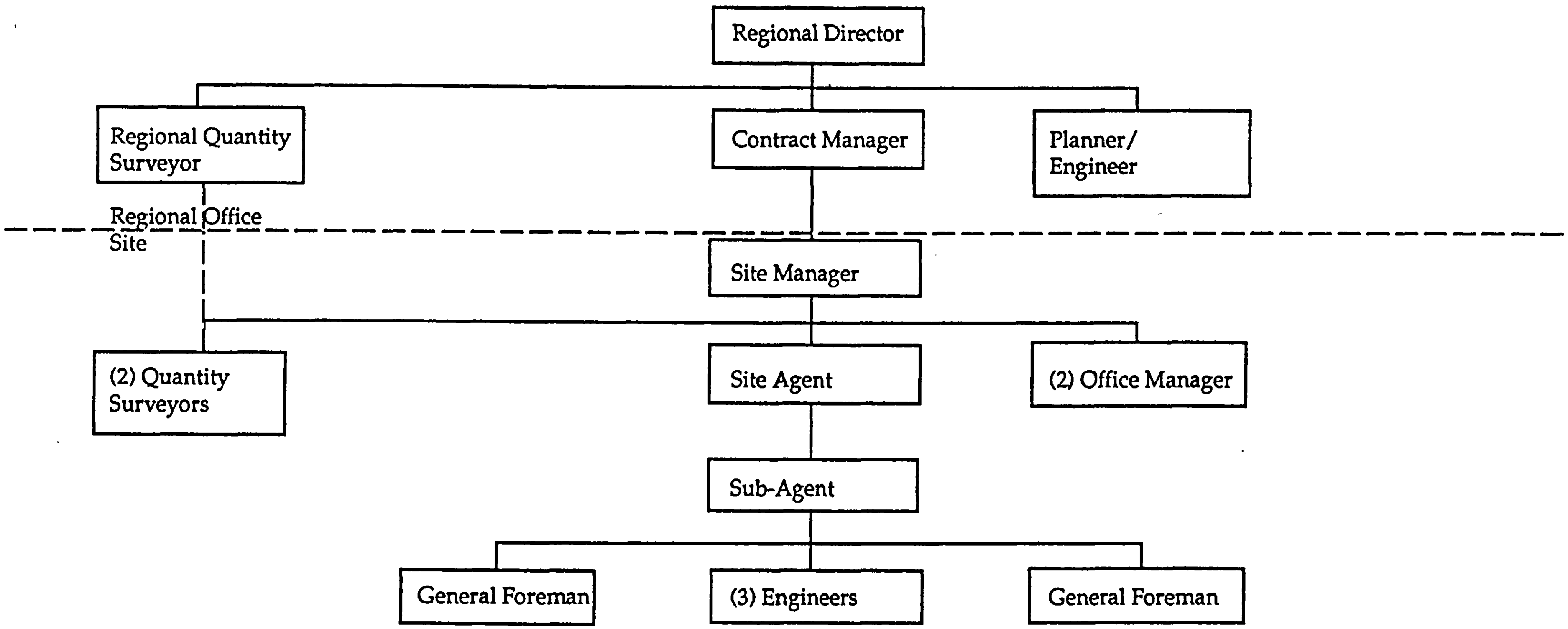
Project Delivery System

The client's agent invited 6 contractors to submit competitive tenders based on the detailed description of the work which had to be carried out. The drawings supplied in the first instance were sufficient to allow the pricing, and additional working drawings and details were provided by the corresponding subcontractors. Although the main contractor could rely on his experience and capability for the construction of major building works, including the work in the public sector, this was the first prison project and required careful preparation and submission of a realistic tender. The client used the PSA as the agent to promote the project and to remain accountable for the services provided. The PSA employed its own professional engineering staff to undertake the design in conjunction with an outside agency of consulting engineers for some part of the task. The agent had maximum involvement in determining the strategy of the contract, ensuring the availability of information, authorisation of variations, and in monitoring the site progress. The agent's team included an architectural team, a resident quantity surveyor and a resident project manager, and three groups of consulting engineers who were the mechanical and electrical engineers, the civil and structural engineers and the public health engineers.

The main contractor decided to manage the contract from the regional office and to supervise it from the site through a process which was centrally managed and directed. The regional director appointed a contract manager to be the link between the regional office and the site and to occupy a role as an instigator of information and feedback system and also apply a system of dissemination and provision of resources. The main contractor's site organisation consisted of 12 employees and was headed by the site manager who was chosen for his ability in adjusting the working procedures to suit the particular needs of the contract. Due to the dominant presence of the client's representative the site manager was expected to reduce the manipulative powers of any outside party by controlling the lines of communication and contacts and by liaising effectively with the client's project manager and the quantity surveyor.

The site organisation was established without attempting to repeat the previous management structures, but to reflect its function and its need for skillful co-ordination of subcontractors who were handling approximately 90 per cent of the work by value, which was divided into 35 main packages. At the time of interview, 50 people were employed on the site including the 12 management personnel in the site organisation. The organisational chart outlining the formal management structure of the site is given in Figure 2.8.

Site Organisation Chart, Figure 2.8



Case Study 9

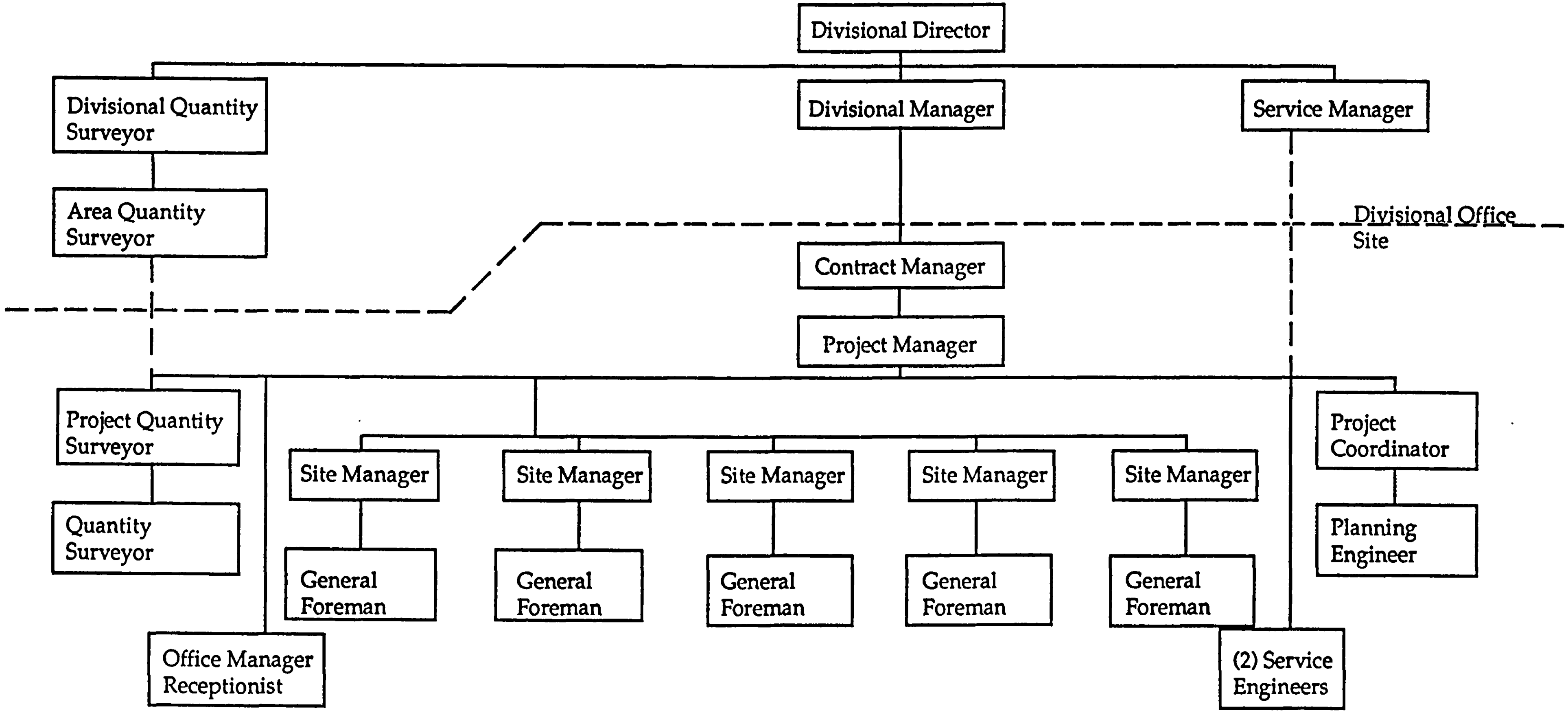
Project Delivery System

The client's brief gave the PSA the opportunity to examine various contractual models against the requirements for the prison development in the shortest possible time in the low density island site. The management contract was finally selected, although it was not the automatic first choice of the client and the in-house PSA team. The total of 10 management contractors were invited for competitive tender late in the life of the project after the planning approvals were obtained and the outline designs were prepared. The tender price was based on the preliminary cost including the overheads plus a management fee. The contract stipulated that all the individual construction contracts and the common site services were to be executed under subcontracts to the management contractor, and the subcontract conditions defined the responsibilities in the event of damage or default. The management contractor was required to identify problems at the work face and issue the notices of default or damage together with instructions to ensure fast and positive corrections.

The Home Office retained the traditional client responsibility for the final approval of design, the placing of construction and service contracts and approval to commit expenditure. The PSA as agents to the client held the full range of contract responsibilities for the preparation of all the drawings, specifications, cost planning and control, contract documentation, tender letting and authorisations, post contract supervision and the preparation of final accounts both for the main management contract and the individual subcontracts. An in-house, multi-professional design team headed by a group manager was especially established for this project. The team also included a project manager and a system project manager who attended the site meetings and the client policy meetings, a project architect who was the supervisory officer issuing instructions to the management contractor, an architectural team including the landscape architect, a public health engineer, a mechanical and electrical engineer, three liaison officers to link the design team to different elements of the work and the corresponding contractors, a quantity surveyor, and an assistant quantity surveyor on the site whose task was to inspect the work on behalf of the client to ensure that it conformed to the architect's drawings.

The management contractor did not carry out any portion of the construction and each element of the work was let out on a competitive basis to 65 contractors and trade specialists who provided the supervision of labour on their own section of the work. The management contractor's site team was headed by a resident contract manager whose responsibilities included the selection and co-ordination of site activities, liaising with the client's design team, taking corrective action where adverse trends were apparent, reporting to the divisional manager, and providing leadership and direction to the site team. The site organisation was structured by considering the task requirements associated with the conditions of the site layout and the dispersed arrangements of the buildings allowed for by a series of courtyard spaces which were large in scale. The site was divided into 5 operating zones, creating the dispersal of the operating functions and widening the span of control of the contract manager. However, this dispersal did not minimise the interdependence among activities and the zones were tied together to maintain overall control. The management contractors site team consisted of 20 staff whose presence on the site depended on the type of activity undertaken at various stages of the programme and the amount of supervision required for each package of work. The organisational chart, depicted in Figure 2.9 , was formed from scratch and its configuration remained unchanged throughout the project.

<u>Site Organisation Chart, Figure 2.9</u>



Case Study 10

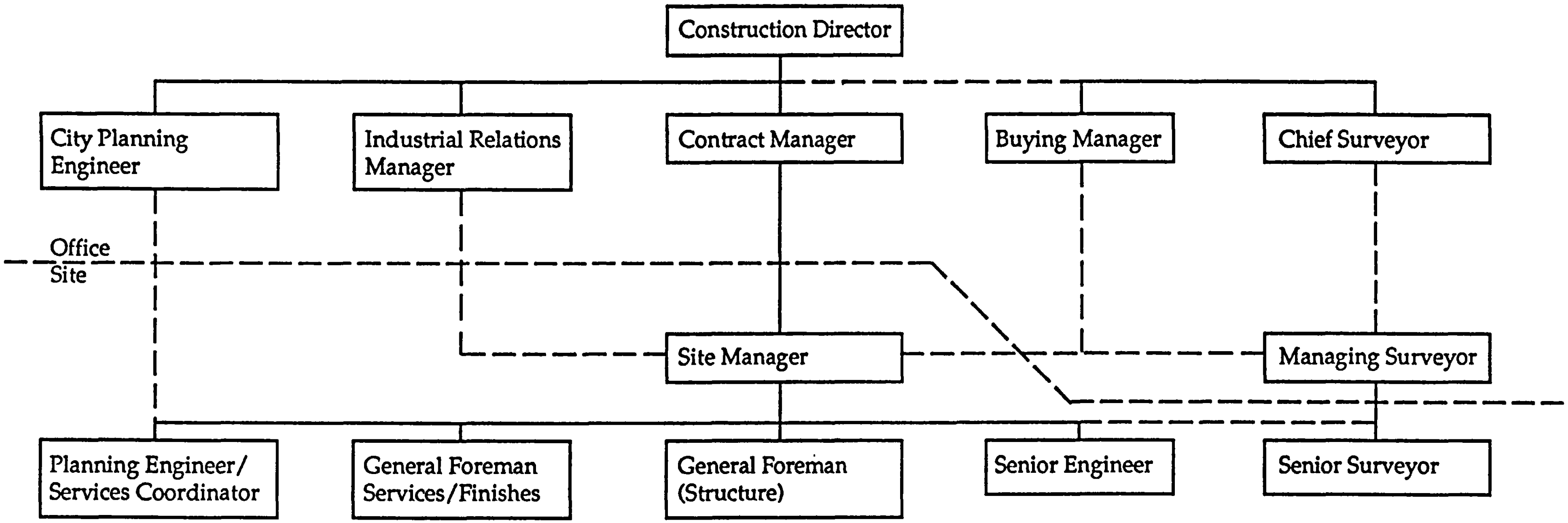
Project Delivery System

The client employed the system of project management to apply management skills and to control all the aspects of the project for a comprehensive covering. A project manager was appointed as the client's agent who assumed total responsibility for the management of the project and for the contract performance of all the participants including the main contractor, and was the sole contact with the client. In order to provide the project management services, the project manager formed a limited company and integrated the activities of the architect, the quantity surveyor and the engineering consultants to separate the management of the design process from the construction process. Although he remained as an executive manager with a co-ordinating role, most of the site supervision was conducted by the assistant architect. The architect had the dual responsibility of producing the designs and drawings, and also site supervision through his assistant architect, who was appointed to the site to communicate with the site staff and give verbal descriptions of needs and to make sure that details were understood. The assistant architect used to participate in the site and office meetings and reported directly to the architect and the project manager. In the view of the main contractor this contractual arrangement was inefficient and often caused disagreements between the design team and the main contractor. The architect and the rest of the design consultants were not able to perform a professional role due to unnecessary intervention on behalf of the project manager as he was a single person who was nominated to provide a single interface between the client, the designers and the main contractor.

The desirable benefits of early contractor participation were not brought about and after the design was substantially completed and the bills of quantities drawn up, 5 contractors were invited to submit their tenders according to the traditional arrangement stipulated in the JCT 80 contract form. The main contractor carried out 10 per cent of the work by value and the remaining portion was let out on a competitive basis to approximately 40 subcontractors and trade specialists whose activities were supervised and co-ordinated by the general foremen. The main contractor's regional office was headed by a managing director who had appointed a construction director to run the preferred contracts and to have the ultimate responsibility as the most senior manager in the management structure. The construction manager delegated the responsibility of setting up the site organisation to a contract manager who provided a clear procedure for communication and a clear definition for interfaces between the contributing members, and also selected the site manager and his site team. Due to the preferred status of the contract, the site manager was released from his duties and was selected for this job because it was believed that he had considerable understanding of building processes and costs and has proven management ability. The site organisation was initially set up with 7 staff. However, very soon into the construction phase it was realised that a liaison officer was required to co-ordinate the input and output of information with the designers and major subcontractors. His function was separate from supervision and he was directly responsible to the site manager.

The organisational structure of the site did not alter at any stage of the construction and the only change encountered was the type and number of personnel according to the programme requirements. Also, at various stages of the work, 7 operatives were employed for those activities that were directly handled by the main contractor. The organisational chart is depicted in Figure 2.10 and includes all the services that were provided by the regional office.

Site Organisation Chart, Figure 2.10



Case Study 11

Project Delivery System

The client with little in-house management resources decided to select an architect to act as the design team leader and offer impartial advice on technical and financial matters to the client. In addition to producing the best design solution, the architect was required to undertake the co-ordination of the work of other consultant members in the design team and to assist the client in selecting the main contractor. In order to save time, the contract was not put on tender and instead the architect provided advice on negotiation procedures for the selection of the main contractor. The architect drew up a short-list of four local contractors and made interviews to assess their suitability according to how well they could meet the project requirements. The architect preferred to retain an element of competition and asked the contractors to submit rates and propose budgets and programmes for the project before the final choice was made. The negotiations were based on a full bill of quantities and the client appointed a quantity surveyor to appraise the market level of the negotiated price. The quantity surveyor also provided additional cost advice and cost control services during the course of the project.

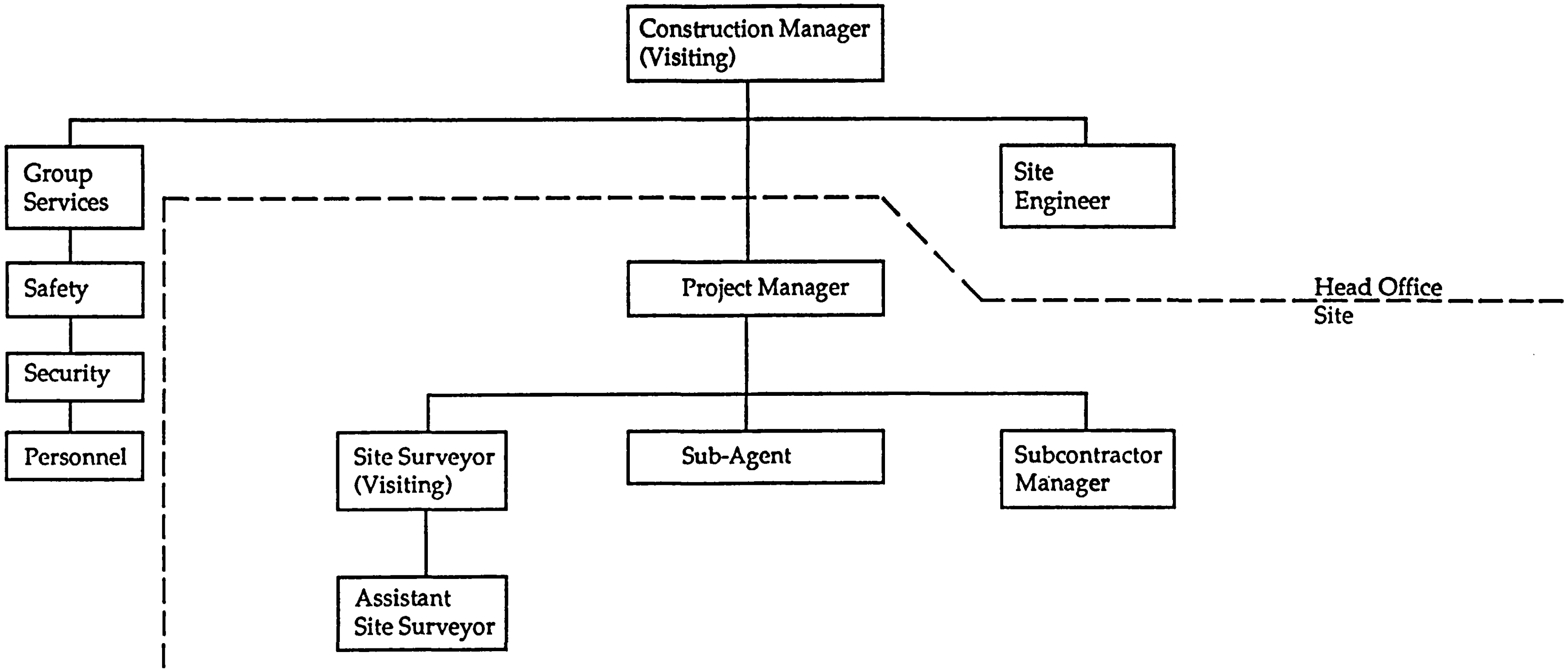
As the project manager, the architect took an active interest in the progress of the site activities by making regular visits and ensuring that he was accessible to answer queries. He conducted weekly meetings with the participation of the client and the structural and services consultants, and appointed one of his assistants to reside and represent the client on site as the first point of contact with the site organisation.

The construction manager who was responsible for administrating the contract set up the site organisation according to the size and complexity of the project and established concise and unambiguous working conditions which gave a clear picture of division of responsibility between the site members and the head-office staff. The site organisation was not highly formalised since heavy emphasis was placed on experience and ability of the project manager to control and plan the direction of the project in accordance with the overall objectives. The project manager headed the site organisation and was in control of the site procedures and was responsible for the progress in relation to time and budget. He was required to provide weekly and monthly reports to the head-office and make financial historic assessment of the site performance.

Subsequent to awarding the contract, all work parcels were let on a competitive tender basis to various subcontractors, with pre-tender selection interviews and post-tender reconciliation meetings attended by the project manager and the architect. There were eight main subcontractors who participated both in the detailed design and construction of the project, and they included the scaffolding specialist, concrete and substructure subcontractor, ground work subcontractor, roof specialist, services subcontractor for mechanical and electrical works, general labourer, brick and block layers, and plant operators including the crane driver. It was estimated that at peak, 60 per cent completion, there would be 30 operatives and labourers working on 14 parallel operations.

The project manager led the site team comprising the sub-agent, the subcontractor manager, the site surveyor who was also responsible for other contracts and was not permanently stationed on the site, and the assistant site surveyor. Apart from the construction manager and the site surveyor who were visiting staff, the organisation remained unchanged for the initial fourteen weeks of the programme and it was expected to remain as such until the final stage of clean up and handover. The site organisational chart is depicted in Figure 2.11.

Site Organisation Chart, Figure 2.11



Case Study 12

Project Delivery System

The client saw an advantage in a single contractual relationship with a design-and-build contractor largely because repeated contracts of a similar nature had been successfully undertaken that had inspired the confidence of the client. The tender was negotiated and the desirable benefits of early contractor participation was brought about when the client directly appointed the contractor to be responsible for the whole process from initial briefing to the production of the finished building. The client organised his own taskforce to liaise with the contractor and appoint the architect to participate in the design process and provide advice. The architect was retained by the contractor and was employed as the project manager in the site organisation to supervise the construction and represent the client. This arrangement worked well for all parties since it contributed to better communication and established close collaboration enabling variations to be introduced and accommodated by negotiation resulting in minimised disruption of the programme.

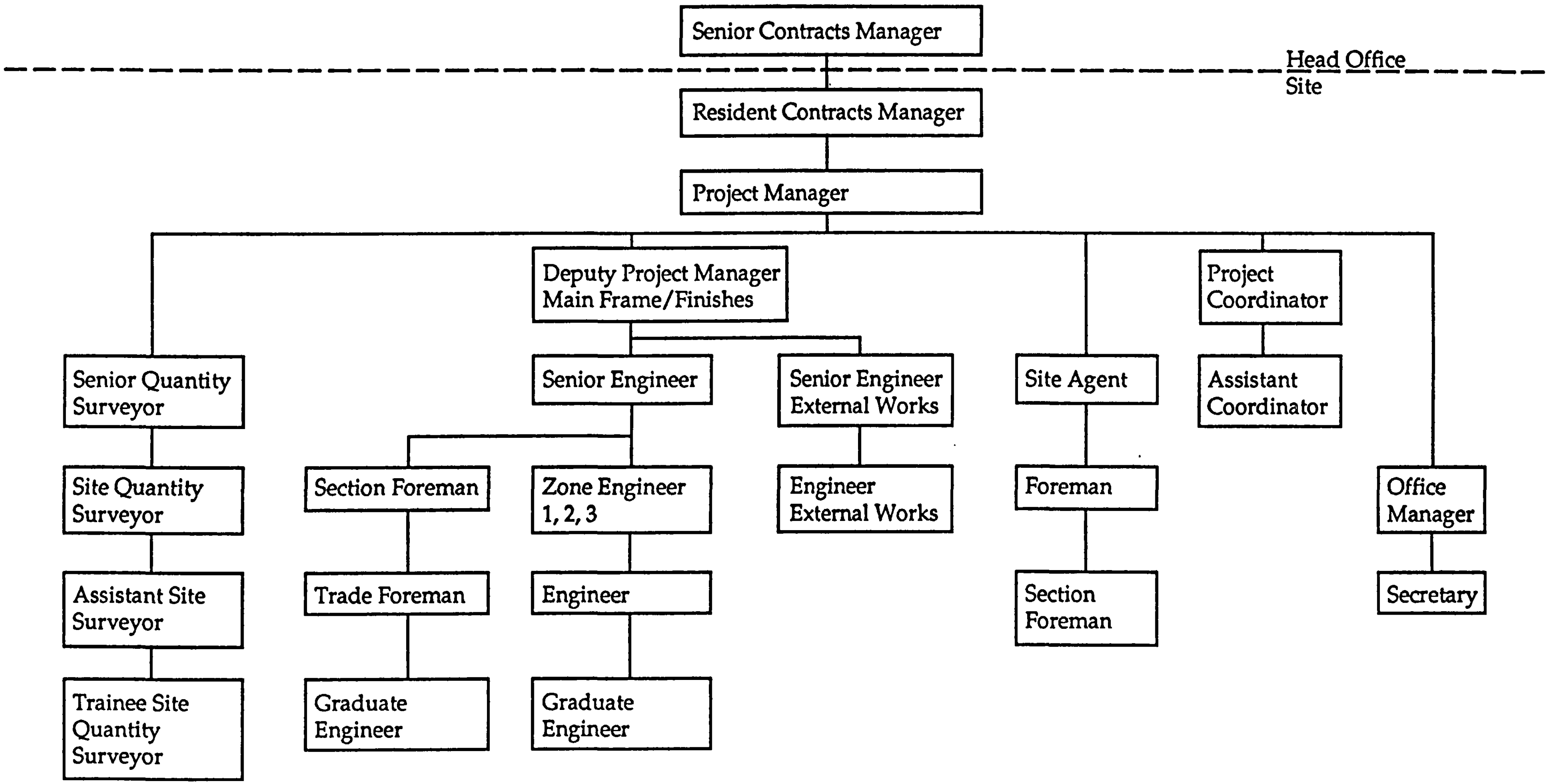
The contractor engaged his own in-house design team to provide the design and engineering services. However, the management of the contract was separated from the management of each separate design function although the processes were linked and co-ordinated by the contractor.

The senior contracts manager who had the overall responsibility for the management of the design and the construction process, delineated all the required tasks and combined them into positions according to general and specific needs. This procedure began with the knowledge of previous structures that were particularly successful in similar situations. The resident contract manager was appointed to run the contract and lead the site organisation which was formed to cover the operations of three work areas and to maintain the integrated functional structure. Due to the size of the organisation, which consisted of 23 site staff, and the differentiation effect of operating in three different zones, emphasis was placed on the ability of the organisation to co-ordinate and hence perform more administrative duties within the site office. Also, the involvement of the quantity surveyor, the architect, the design team and the site team all with direct contractual links with the contractor, expanded his functional role and created a pull towards centralisation and direct supervision by the line managers.

The use of subcontractors was extensive and over 90 per cent of the job was broken down into smaller work packages and subcontracted. The parcels were let on a competitive tender basis with the contractor retaining overall project control and providing basic site facilities and attendance. The remaining 10 per cent of the job was handled by the contractor who employed 30 operatives and labourers at various stages of the project to carry out the work. There was also one nominated subcontractor selected by the client to undertake the detailed design and the shop fitting. The subcontractor was selected by a series of pre-tender interviews conducted by the architect, although his contractual relationship was with the contractor. In total 50 subcontractors were appointed by traditional competitive tenders who provided their own labour force and supervision for most of the building activities on the site.

The site organisational chart, indicating the positions and formal channels of communication in the management structure, is given in Figure 2.12.

Site Organisation Chart, Figure 2.12



Case Study 13

Project Delivery System

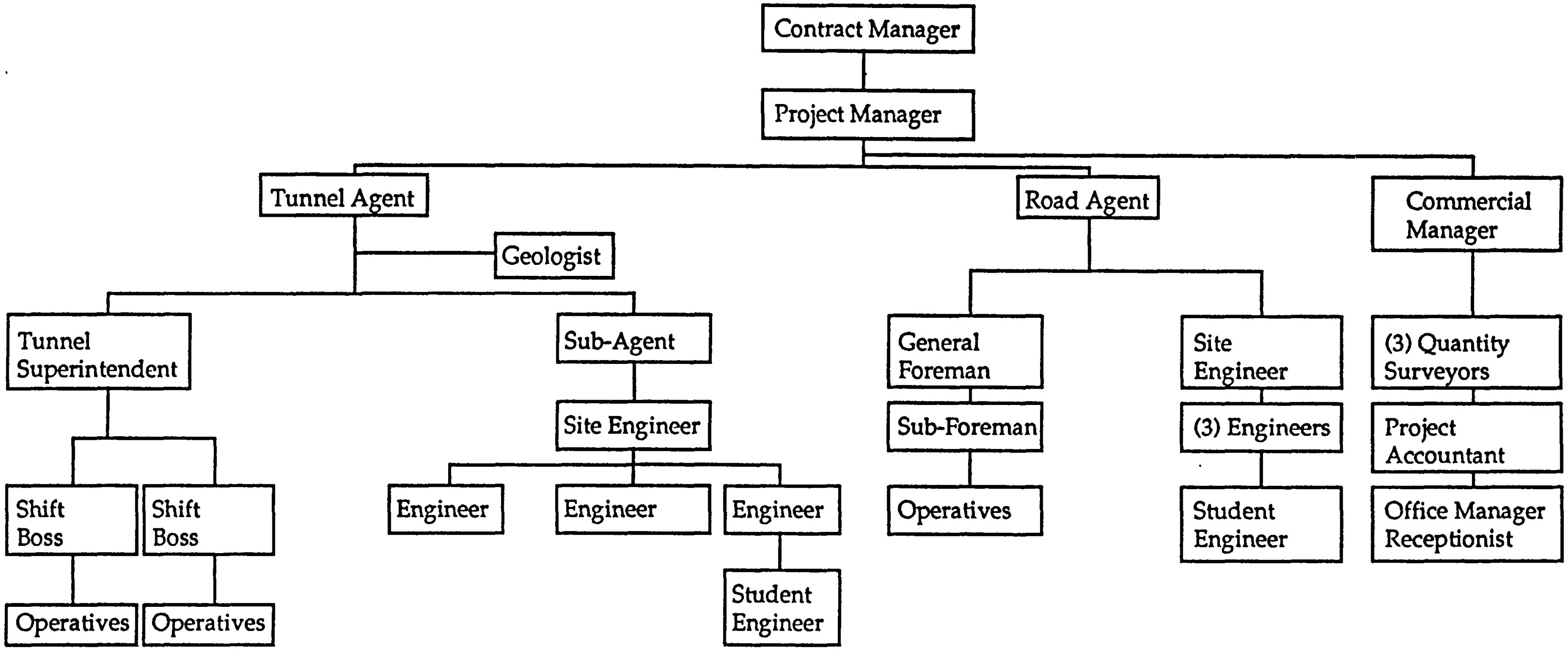
With the completion of the statutory procedures and the preparation of the conceptual and preliminary design by the client's engineering consultants, the tender documents, based on the itemised bill of quantities, were drawn up according to the standard civil engineering contract form ICE 5th. Six civil engineering contractors participated in the competitive tender. They were selected based on their scope of civil engineering activities including tunnelling of various methods and in all types of ground conditions.

The client formed his project team by appointing a group of six engineers who were employed at the Highway Department of the Welsh Office to represent and participate in monthly meetings with the main contractor and liaise with the site organisation through the project manager. The client's project team did not take an active interest in the safety aspects of the operation or the quality assurance. However, they used their testing facilities to constantly check the strength and specification of materials as outlined by the engineering consultants. Two firms of engineering consultants were appointed to provide the design and engineering services and to supervise the site activities to make sure that the design standards were adequately observed. Due to the inevitable and significant impact of the road improvement scheme on the North Wales recreational areas and the rural scenes, every effort was made to reduce the negative effects on the environment. The services of an architect were acquired to assess the environmental factors and consider the extent of the damage to the landscape and ecology, and the effects of visual and noise intrusion.

The contract was awarded to the central division of a UK based construction company which was established to mainly undertake civil engineering contracts in the North Wales and Midlands regions. Stationed at the head-office a contract manager was appointed to structure the site organisation and to run the contract. However, 7 months into the programme he was transferred to another project and was replaced by a newly recruited contract manager whose responsibilities were limited to ensuring that company site procedures were carried out, to see that engineers were satisfied with the procurement and delivery of materials, and to overview the overall progress of the contract. The primary responsibility and control of the site activities were delegated to the project manager who resided at the site office throughout the contract as the head of the site organisation. The site organisation was composed of 27 technical and administrative staff and were assigned to the project according to the management structure illustrated in Figure 2.13 with the operational control of the tunnel and road disciplines under two separate agents. Due to the demands of civil engineering works, the organisation contained a large proportion of technically skilled people in different trades who were accommodated in a relatively horizontally specialised structure. Throughout the life of the project the fundamental aspects of the structure remained unchanged. However, at various stages of the contract depending on the type of operation and the resource requirements, some portions of the organisation evolved to conditions different from what was originally set. It was expressed that in setting up the future organisations for similar projects, the appointment of a chief engineer should be considered to control the overall technical and planning activities as a co-ordinating function. The majority of the work was performed by the main contractor who at peak of activities employed

80 operatives and utilised the services of 30 subcontractors to handle 30 per cent of the work by value which included the construction of the flexible pavement and road surfacing.

Site Organisation Chart, Figure 2.13



Case Study 14

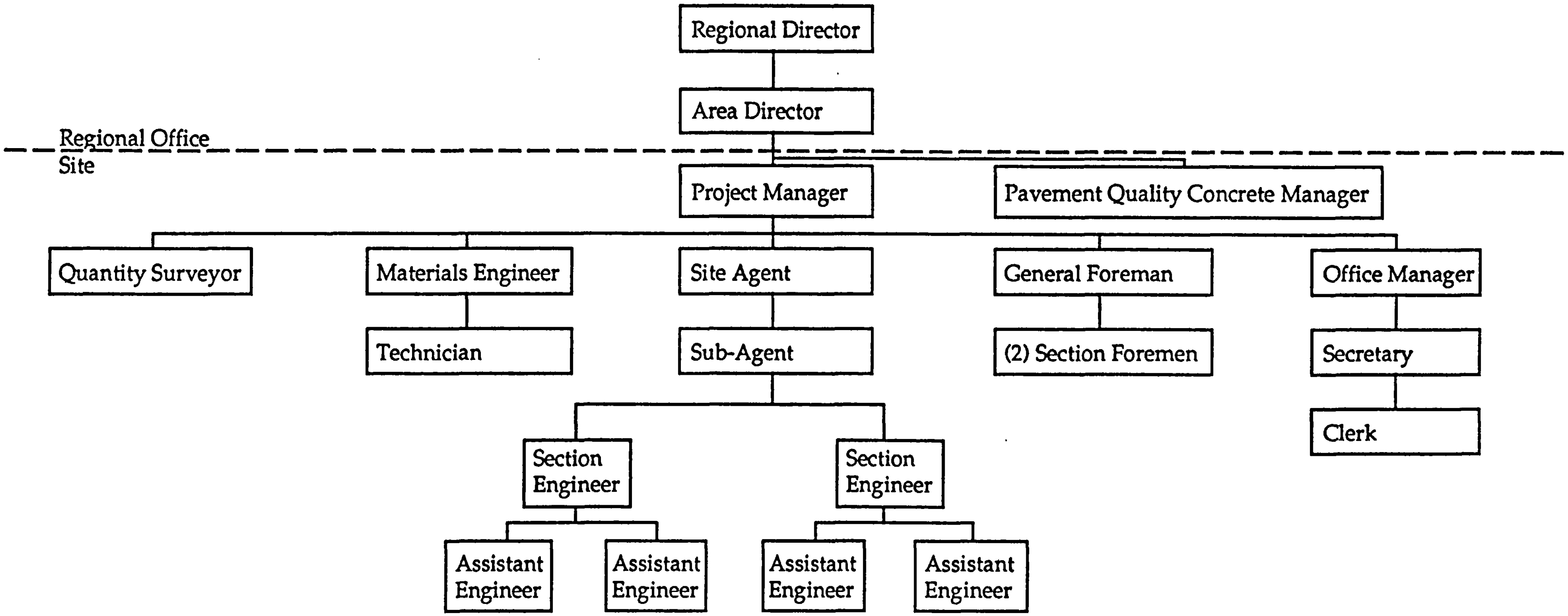
Project Delivery System

The British Airports Authority decided that management contracting route should be used for the expansion scheme because it was considered that the project was too large to be handled by a single national contractor operating on traditional lines. Consequently, after successful competition a major management contractor was appointed by the client to be responsible for all construction work both temporary and permanent, and offer cost and time saving advice to maintain the required target completion dates. The management contractor's planning department covered four principal aspects of planning, programme co-ordination, progress reporting and drawing administration and estate management of all temporary facilities, including common services and security. The project master programme produced by the management contractor provided design release information, package tendering and order placing, together with design development, off-site manufacturing and on-site construction. The work packages programme was the primary control document used during the early stages when letting the major packages, and subsequently the principal control was governed by the individual contract programmes and the release of design information, which in some instances necessitated resequencing the work to take account of design development. However, for this particular package-contract, programme was provided and administered without requiring major resequencing of the work since the detailed design was produced prior to the commencement of site activities.

Tenders were invited on a selective basis from six contractors by the management contractor in consultation with the client after extensive interviews and investigations. The procedures adopted in preparing the selected list were primarily concerned with establishing technical competence, financial standing, previous experience in airport construction and a capability to carry out civil engineering works. The contract was awarded to the South East regional office of a UK based contractor whose area director held the overall responsibility to run the contract and establish the most appropriate site organisation which consisted of 18 staff. A project manager was appointed to direct the organisation and co-ordinate the activities of all the participants, including the subcontractors, to achieve the completion of the project to programme and within budgeted cost. In order to avoid fragmentation and to promote effective communication the project manager attended regular progress meetings and liaised with the management contractor's civil works manager to ensure that construction works were carried out in accordance with the requirements and performance criteria.

The site organisation, Figure 2.14, experienced very little change during the course of the project and did not evolve to new forms as the work progressed. However, after the completion of the sub-base and the drainage system, a pavement quality concrete manager was introduced into the management structure to participate in the supervision of the concrete work and the quality control procedures. Consistent with the policy of centralising contractual responsibilities the client avoided the use of nominated subcontractors. Instead the civil engineering contractor directly employed the subcontractors to handle the majority of the work including earthwork and removal, soil stabilisation, asphalt surfacing, and cabling and connections for the lighting system, and employed 32 operatives to perform the minor tasks.

Site Organisation Chart, Figure 2.14



Case Study 15

Project Delivery System

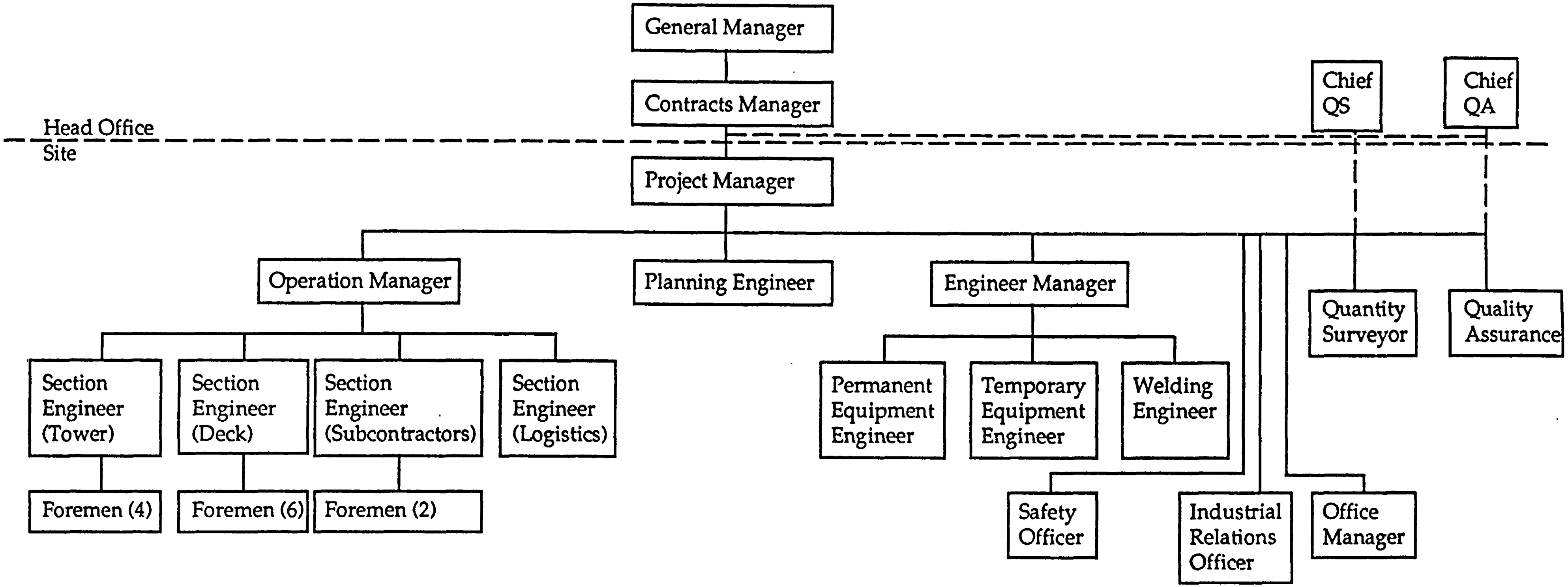
Two contractors were invited to follow the process of competitive tendering according to the formalised procedures described in the contract. The contractors were required to fully conform to the specifications and avoid any modifications in order to be qualified. To satisfy the client's requirements a number of amendments were introduced which resulted in a highly tailored version of the ICE 5th standard form of contract.

A consulting engineer was employed to join the client's in-house design team and to represent the client as the administrator of the contract. He was not stationed at the site, but made frequent visits and participated in site meeting mainly as the representative responsible for liaison both within his organisation and with the contractor's site organisation.

The main contractor as a subsidiary company provided a comprehensive coverage of the UK through its network of regional offices and acquired a diversified portfolio of contracts in construction and construction-related services to the oil, gas, chemical and nuclear industries. The expertise of the company was in the management of mechanical projects including the construction of a large variety of industrial plants and the installation of complex steel structures. Although this project came under the jurisdiction of the Mechanical Construction Services, it required a great deal of bridge engineering which the main contractor lacked in the in-house expertise and experience. Thus, to cope with the requirements and scope of the project, three engineering consultants were employed for their services in the design of temporary works and plants, the design of permanent features and the design of construction methods. Due to the size of the contract the head-office took an active role in controlling various aspects of the job such as preparing the work schemes and methods for the temporary works and giving assistance for the general co-ordination of the supply of the main materials, and providing technical and commercial services to the site. At the tender stage the main contractor specified the management system and the manpower and skill demands. However, very soon after the commencement it was realised that the site services of an engineer manager and his staff of three engineers for the permanent equipment, the temporary equipment and the welding operations was required. The selection of the permanent equipment engineer was based on the recommendation of the client and the engineer's previous involvement in a similar project.

The site organisation employed 28 technical and managerial staff and was headed by the resident project manager who had the responsibility of providing monthly reports to the contracts manager. The contracts manager directly appointed the site staff and structured the site organisation, Figure 2.15, and co-ordinated the services of the head-office provided to the site. Approximately half of the operatives, who were 170 at the peak of the operation, were employed externally from the locality of the site and were brought in by various subcontractors who handled 50 per cent of the job by value.

Site Organisation Chart, Figure 2.15



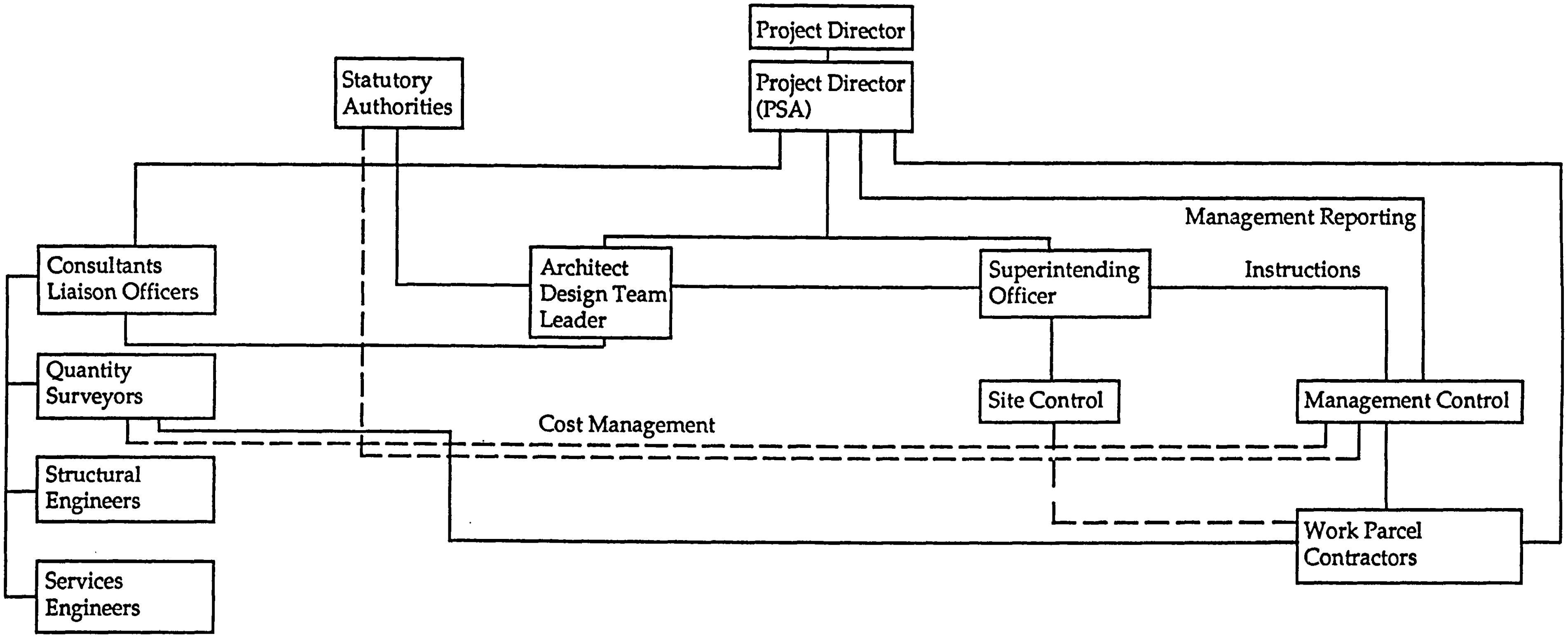
Case Study 16

Project Delivery System

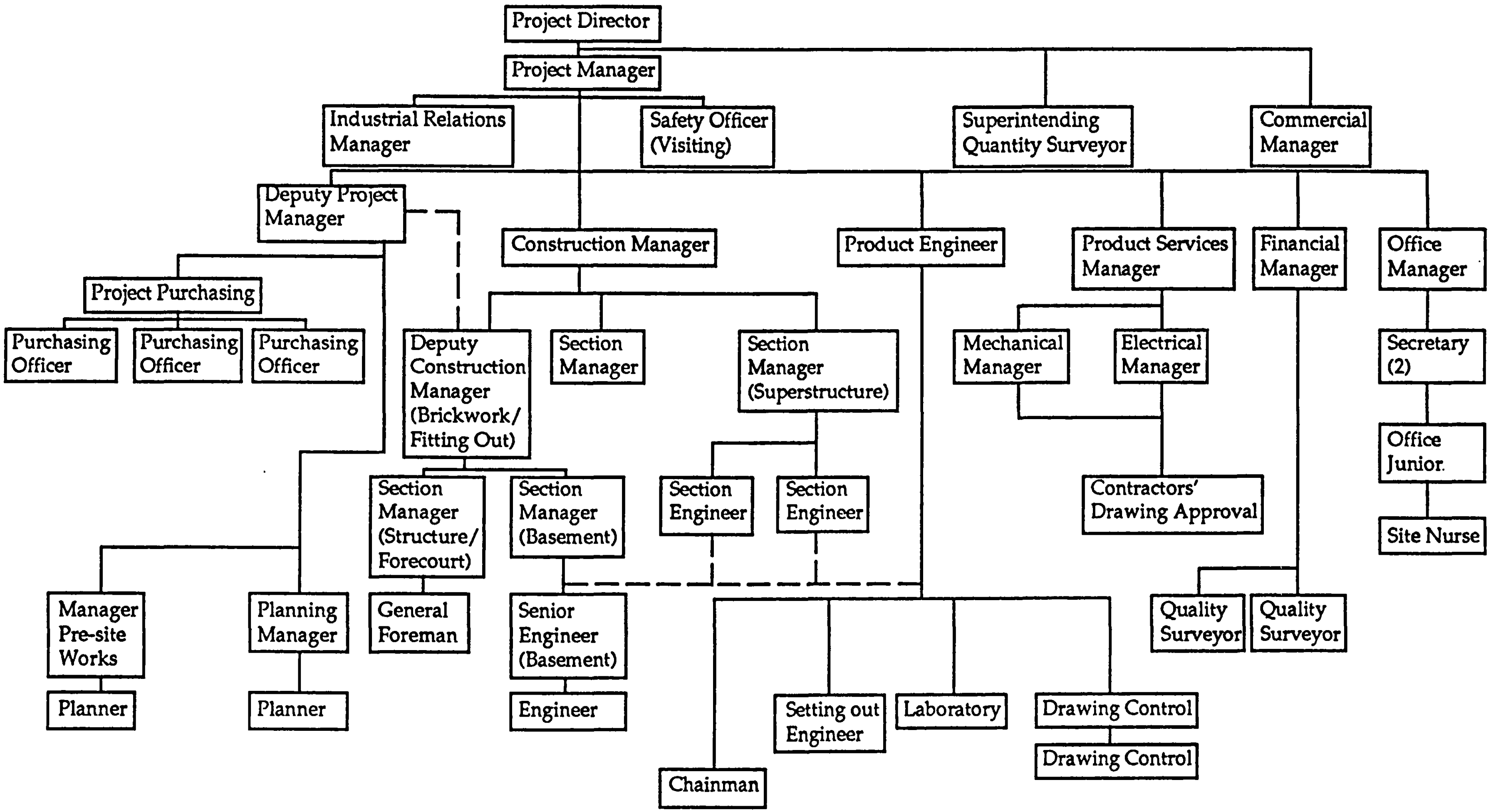
The British Library is being constructed under a construction management contract by a management contracting firm, and the project is managed by the PSA's Directorate of Civil Accommodation for its sponsor client, the Office of Arts and Libraries and the user client, the British Library. In contracting terms, the British Library represents a new venture by PSA into construction management where the contracts with the trade contractors are held directly by the PSA, while the management contractor provides a management service. The PSA's decision was based on the theory that since the management contractor carries financial risks of possible failure by the subcontractors, the degree of co-operation with the client to complete the project to time and to cost would be reduced. Thus, it was agreed that the PSA would exonerate the management firm from such risks by taking direct action against failing subcontractors through the construction management method. The extra responsibilities entailed in construction management are undertaken by a total of 11 PSA staff at the British Library. The management structure implemented by PSA introduced multi-disciplinary project roles and provided a broad view to ensure that the organisation is flexible enough to provide continuity and thus a good service to the client. However, a lack of continuity has been experienced since PSA has had many staff changes including three project managers in five years. Due to participation of many groups of professionals, as depicted in organisational relationships Figure 2.16(a) has required co-ordinating the efforts of the PSA, the consultants, the management firm and the trade contractors by carrying out a series of regular meetings at various levels and passing the information through memoranda which are circulated among all the participant teams. The Office of Arts and Libraries appointed a project director to head the organisation and to act as the focal point for the client and help to discharge the responsibilities arising from the client ownership of the project. An architect, whose firm is in contract for about 70 per cent of the work and who has an intimate knowledge of the design and the intentions, has been appointed as the superintending officer in charge of supervising the work beyond the preliminary site works and keeping the project up to standard and releasing instructions to the management contractor. He has to ensure that the management contractor and other contractors fulfil their responsibilities in accordance with their respective contracts with the PSA. The contract arrangement allows the design and construction to proceed concurrently and therefore in order to keep the production of drawings up to the information flow, the superintending officer has recruited an extra architectural specification writer to help to increase the output.

The management contractor's involvement concerns the control of the works of companies whose contracts have been signed with the PSA. The process of staged letting in this form of management contract has permitted flexibility in programming, by giving consideration to the accommodation of possible delays by adjusting the time span of each parcel of work and by resequencing operations within a zone of the site. Also, this has allowed flexibility in design and in budgeting control so that decisions can be reached at a date much later than is required in traditional contracting. Prior to commencement, the management contractor was committed to the drawing up of and getting agreement to many procedures such as the planning and documentation for all the necessary control of the working of the contracts, both pre-site and on site. The firm produced a master programme which has formed the basis for the sequencing and timing of the design information and the eventual work on site in a time span according to the desired completion dates. The procedure documents have dictated how all aspects of the work should be organised and controlled through from the placing of a contract with a specialist company to the hand-over of the works. At the time of interview, there were 44 site staff including the general management, civil, mechanical and electrical engineers, quantity surveyors, resource planners, purchasing and supply managers, administration and secretarial staff, and 250 operatives working for the five main contractors and various subcontractors. The management contractor's site organisational chart is presented in Figure 2.16(b).

Organisational Relationship, Figure 2.16(a)



Site Organisation Chart, Figure 2.16(b)



Case Study 17

Project Delivery System

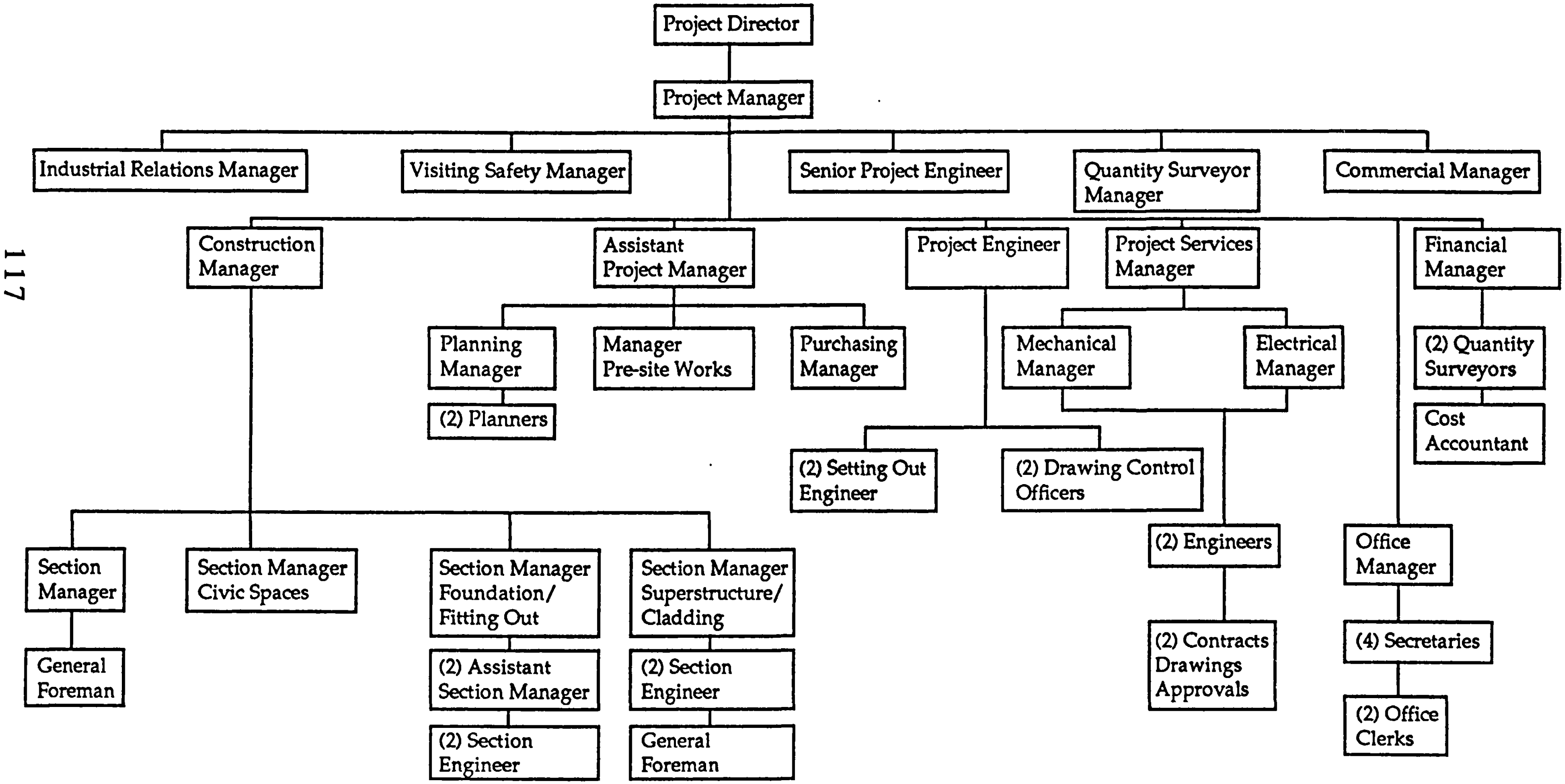
The client and his representative negotiated a set of conditions and prices with various members of the professional team and with the trade contractors on the basis of the scheme drawings and specifications. Due to the insistence of the client a hands-on approach was adopted and the whole process of design and construction was rethought to introduce a more imaginative procedure of phase construction and fast-track management techniques in an effort to ensure faster project completion. Contract documents were completely rewritten to include the client's conditions of providing penalties for designers and contractors for late delivery of drawings and hand-over, and there were no provisions for extensions due to inclement weather. All contracts with consultants and contractors were based on fixed price and fixed time.

In order to bridge the traditional gap between client and contractors, the developer directly employed all the trade contractors and used construction management. A British contracting firm was selected to provide construction management services and an American project management firm was brought to Britain as the construction adviser to the fast-track programme. After the completion of the first four phases, the construction adviser formed a joint venture with the British firm to work on the remaining phases. The responsibilities entailed in construction management included constructibility recommendations, contract document packaging and co-ordination, planning and scheduling, materials management and field materials control, review of contractor submittals related to field methods to determine compliance with the contract, site layout and access and temporary utilities. The constructibility recommendations were available in the early phases of design, where schematics and specifications were being considered, for the main purpose of minimisation of construction interference and detail improvement.

The client employed his own construction director to supervise the building programme from the start of the feasibility study until completion, and to represent the client by visiting the site at least two days a week. He participated in the selection of trade contractors who were appointed according to ability and interest shown in the project rather than price. Although cost was of secondary importance, it was considered from the design stage with the help of quantity surveyors as cost consultants. The number of trade contractors interviewed was not more than four for each package and many of them were invited back to participate in the future phases. The client adopted a strong selection process for the appointment of the professional team with the emphasis on the integrated design services. On the first four phases a British design consultant provided the basic services of architecture, structural engineering, electrical and mechanical, and quantity surveying. During the early phases an American building services consultant was employed to provide limited consultancy work. However, for the rest of the phases the client approached the company to act as the full services consultant for the fit-out stage of the shell-and-core contract, replacing the British firm. The final fitting-out operation for each building was handled separately by consultants under tenant's contract.

The construction management was employed on a fee basis as part of the professional team with all the responsibilities outlined above. Although in the USA the construction manager frequently manages the design teams as well, in this project the client's construction director preferred to maintain neutrality with and between the professionals and prevent them from being over-managed. In the construction management organisation a construction director was chosen to have the ultimate responsibility of managing the project and encouraging the use of new construction techniques. His approach contained an American influence, since he visited a Chicago-based architect to observe the design process and investigate the construction techniques of similar contracts. He led a management team which was set up as an autonomous unit with an on-site project director and a group of 50 technical and managerial staff. The site organisational chart is given in Figure 2.17.

Site Organisation Chart, Figure 2.17



Case Study 18

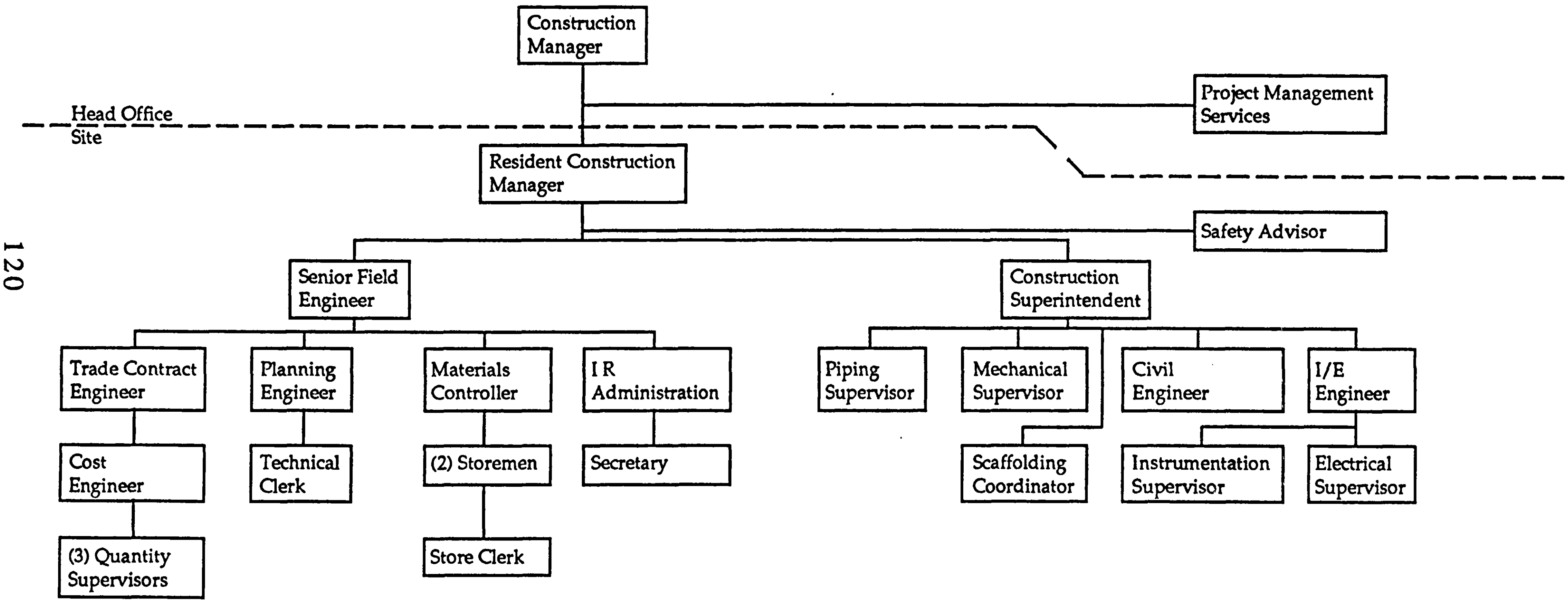
Project Delivery System

To blend the required process and design engineering experience with sophisticated management systems, the client decided to acquire an integrated design and management contracting service. The contract was awarded to a process engineering contractor whose scope of work included detailed planning to integrate the new construction works and ensure that all construction for all disciplines took cognizance of the primary requirement of the continued uninterrupted production of the factory during the specified periods. The type of contract was cost-plus and the contractor was reimbursed for all the costs incurred during the fulfilment of the contract, plus an agreed fee to cover overheads and profit defined as a percentage of the actual cost. The client introduced competition into the award of the contract by adopting a two-stage tendering procedure. A group of consulting firms were invited, against reimbursement of their costs, to participate in the development of the brief. The preferred concept then formed the basis of the tenders.

The client was represented by a project manager who took up residence on site. All the prime dealings were through the client's engineering department. However, the management contractor was encouraged to liaise directly with the production department for some day to day activities associated with obtaining permits, shut down dates and duration, and package hand-over. The client decided that the site staff should utilise the existing project establishment buildings and the store complex. Therefore the original establishment set out which had been submitted as part of the contract bid was not required. The main building needed extensive renovation to enable, not only the site staff to be accommodated, but also the design draughtsmen who would be working with the project engineers.

The site staff positions were filled by permanent management contractor's staff members with the exception of the administration manager, storemen, and scaffolding co-ordinator, who were nominated by the client's project manager. In addition to the 24 permanent staff members, shown in Figure 2.18, at the peak of the operation a few weekly members were employed through an agency directly by the project manager but under the supervision of the contractor's construction manager. To provide the technical support services a multi-discipline design engineering team was formed as a central task force at the head-office. This task force was responsible for the detailed plant design and translating the requirements and specifications from process engineering into work drawings for complete installation. There were no specific requirements with regard to quality assurance and the client did not designate any staff for this purpose. However, the management contractor's standard approach was adopted to ensure that design was reviewed and checked in accordance with the company's procedures and that the responsibility for technical quality and application of satisfactory quality assurance and control practices for suppliers and trade contractors was clearly defined and traceable. All quality assurance activities and co-ordination were routed through the Q.A. manager and Q.C. manager at the head-office.

Site Organisation Chart, Figure 2.18



2.2 DIMENSIONS OF ENVIRONMENT

In this study environment is not looked at as independent entity, but as a collection of conditions with specific impacts on the organisation. Also, the environment is not taken as a single entity, since every organisation faces multiple environments which can be characterised by three dimensions. First, an organisation's environment can range from stable to dynamic. A variety of factors can make an environment change along this dimension, and real problems are caused by changes that occur unexpectedly for which no patterns could have been discerned in advance. The factors that have been identified to influence the stability of environment includes unpredictable shifts in the economy, variations and changes in client's requirements, changes in project goals, and labour shortages.

Second, an organisation's environment can range from simple to complex depending on the comprehensibility of the work to be done, and focuses on whether the factors in the environment considered for decision-making are few in number and similar or many in number and different. The dimensions of complexity is measured by the degree of difficulty encountered in co-ordinating the work of subcontractors due to their numbers or type of activity, the involvement of client and his representatives, and difficulty in programming or controlling the work.

Third, an organisation's environment can range from friendly to hostile. The dimension of hostility affects structure through predictability of the work and more importantly the speed of response, since very hostile environments generally demand fast reactions by the organisation. Hostility is influenced by competition, by adverse relations between involved parties including industrial relations, by project location, and by extreme weather conditions.

We proceed by discussing the theoretical implications, as suggested in literature, of the overall effect of each of the above dimensions of environment on structure and present three hypotheses to reflect the dominant aspects of the relationship between the structure and environment. The objective is to test the hypotheses by comparing the implied organisational outcomes with the actual data, constituting of design parameters, so that any deviation or inconsistencies can be detected. After the hypotheses are presented, environmental conditions of each case will be discussed separately to determine the applicable dimensions and hence the relevant structural implications.

In a stable environment, an organisation can predict its future conditions and thus standardise its procedures from top to bottom, establish rules, formalise work, and plan actions. The structure becomes more rigid and chain of command and responsibility more clear. In a dynamic environment the structure is driven towards an organic state, since the organisation cannot easily predict its future activities and cannot rely on standardisation or formalisation for co-ordination. The organisation uses a more flexible and less formalised co-ordinating mechanism, such as mutual adjustment, and encourages informal communication.

In a simple environment, information can easily be consolidated and understood which enables the organisation to centralise control and co-ordinate at the top of the hierarchy with little reliance on liaison devices and mutual adjustment for co-ordination. When the organisation is faced with a complex environment it encounters problems of comprehensibility and consequently decisions are decentralised to prevent the effects of overloading. Authority to make decisions are delegated among middle-line managers, staff specialists, and trained professionals at the operating core. The units or sub-units possess the ability to take decisions for themselves on issues which are reserved to a higher level in comparable organisations.

The hostility dimension has a special effect on structure through the intermediate variables of predictability of the work and speed of response for fast reactions by the organisation. The hostility demands an immediate, but temporary, centralisation of structure and direct supervision for tightest means of co-ordination and control. When an environment is not uniformly hostile across its range the organisation is encouraged to differentiate its structure and use selective centralisation both in vertical and horizontal dimensions.

The dimensions of stability and complexity each describes a specific structural characteristic that emerges from uniformly treated environmental conditions. However, the above dimensions are more powerful when they interact together to generate specific types of structures, and in particular when they are presented in a matrix form. Also, the dimension of hostility is viewed as imposing a special condition on the two-dimensional matrix. Extreme hostility drives each of the four types to centralise its structure temporarily, irrelevant of the initial conditions.

This approach in analysis is intended to support the argument that much can be learned by focusing on distinct types of structures found under specific environmental conditions, adding depth to the investigation of continuous relationships between structural and contingency variables which will be presented in future chapters.

Hypothesis E1: The more dynamic the environment, the more organic the structure.

Hypothesis E2: The more complex the environment, the more decentralised the structure.

Hypothesis E3: The hostility in environment drives any organisation to centralise its structure temporarily.

Case Study 1

The project did not encounter any changes in scope since the occupant of the property was able to identify his requirements and relay them clearly to the client at the outset of project planning and design. The design was also moved speedily to a finalised form which was understandable by all parties, providing complete and consistent details for the contractor. There were some labour shortages, but this was expressed as a typical factor in projects managed in the South East and hence predictable for the contractor to include provisions during the planning phase. Increases in cost over the amounts expected, basically due to inflation, is considered as common and though might have contributed to high costs of financing the project it did not create any delays or disruptions. There were very little changes in demand for creativity since there were no changes in technology or the knowledge base which made the work or construction activities rather predictable.

The main contractor realised that one factor that increased the degree of complexity was the number of subcontractors and the interdependencies of their activities, highlighted especially during the second phase of the contract. Client's involvement through his representatives did not create any complications in receiving information, reviewing progress, or supervising the work. The objectives of planning and controlling the project as a whole was achieved in a satisfactory manner by understanding the importance of teamwork and at the same time being able to make decisions according to the authority and responsibility of the team members. In particular, the client's ability to define the authority of his management team and the responsibilities for design and supervision prior to the commencement of the contract, was considered as a contributing factor to effective and timely decisions and hence the successful accomplishment of the project objectives.

There were no adverse relations between the organisation and the statutory undertakers supplying gas, water, electricity, and drainage to effect the progress of the project. Other outsider parties such as the local council for planning permission, council for building regulation, the fire authority, and the health and safety authority also co-operated to the best of their abilities to issue approvals as fast as they could. However, among the insider parties there was some friction between the design members, namely the architect, the structural engineers, and the quantity surveyors due to the differences in identifying the major project objectives. The contractor played a mediating role to resolve these problems successfully. The site is located in a well built urban area with good access roads, plenty of space for material delivery and no immediate neighbours. The only hostile element in the environment was the weather which caused minor delays during the summer season. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and friendly conditions.

Case Study 2

An important objective was to implement a design capable of speedy execution using the contractor's expertise on buildability early in the design process. Due to the nature of the contract, contractor's input regarding costs, programme, and buildability was available during the design development. Time had the overriding importance, since the building was the main office of the confectionery firm and the client had considered the cost of the alternative accommodation while waiting to move in.

The architect, with his known client experience, discussed client's requirements including timescale and financial limits and advised on compilation of the client's brief. He attended regular design team meetings to monitor information production and prepare drawings and schedules. He also advised on implications of design changes and the consequent delays and design cost options. The contractor accommodated the variations without disrupting the programme, however, they were one of the important causes of cost overruns arising directly from the changes in the building work. Some detailed decisions were deliberately delayed at the design stage. For example, the final decision on the types of partition and fixtures and their construction and appearance was subject to a detailed analysis between the client and the architect after more specific performance requirements were known. There was no shortage of skilled labourers and their demand during the life of the project was predictable.

The client appointed a single representative who was the only person who could issue instructions to the contractor. Due to an almost continuous building programme and a high level of in-house expertise, there was a maximum of client involvement through his project manager. This was to make sure that a senior member of the project team, who can take decisions without reference back, would be available for consultation when required. However, occasionally, there were confused lines of responsibility and poor communication between the architect and the client's project manager resulting in inadequate project leadership.

The period between the contract award and the commencement of the building activities on site, reflecting how much had already been done to assemble resources and the client's urgency, was three weeks which provided sufficient time for site preparation and mobilisation. The problem of congestion persisted throughout the project, since there was only one narrow access to the second floor of the building, and the number of different trades needed and the number of visits by them made it difficult to properly manage and co-ordinate the activities of the subcontractors.

One complaint about external influences was related to the statutory undertaker supplying gas. They failed to fit their operations into the building schedules and were not prepared to accept the disciplines in terms of the timing of their activities. A high pressure gas pipe ran under the service road which was planned to be covered by the extension wing of the new offices. The statutory undertaker would not allow the service road to be covered and demanded the diversion of the gas pipe before any construction could start. The outsider parties visiting the site frequently were the client's safety and quality control engineers who made regular inspections, and the client's cost consultant who made forecasts concerning the cash-flow and negotiated the final accounts. The client's cost control office functioned separately from the project manager's team on the site and would discuss cost control issues with the contractors quantity surveyors.

Although the site location had easy access, there were physical constraints within the work-area which restricted the labour movements and consequently increased the difficulty of co-ordination. The adverse weather conditions were irrelevant to the project situation since the majority of the work was done indoors. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and friendly conditions.

Case Study 3

The area of the West Country is considered as having a poor record on safety since a large number of small companies operate in that region which do not encourage their employees to be safety conscious. Operating in such an environment it has become a priority for the main contractor to consider quality and safety as the major objectives in any project. In order to monitor the standards of quality and safety, highly trained officers frequently visited the sites to inspect and discuss the relevant issues with the site agents. Throughout the life of this project the priorities remained unchanged and were enforced by the contracts manager. The client considered the date for completion as the most important project objective since it would enable the retailer to begin the distribution of goods in time for the Christmas season.

The main contractor relied heavily on the local labour force, and since it was well familiar with the labour market in that region it was possible to predict accurately and prevent the consequences of encountering labour shortages. However, a subcontractor for the carpentry work was unable to keep up with the pace of the programme and had to be replaced by another subcontractor provided by a local agency. The project was subjected to a number of minor variations and additions which resulted in parties agreeing to an accelerated package to meet the schedule. The project environment remained stable and did not encounter any drastic change in the client's requirements or the fundamental objectives.

The client's architect was responsible for representing and managing the project on behalf of the client, but there were many instances where the client intervened and dealt directly with the contractor by-passing the efforts and advice of his architect. He attended the site meetings and made decisions which were contrary to the recommendations of both the architect and the contractor. For example, since the warehouse was designed to be used as a storage area for clothes the selection of the concrete floor should have been based on technical considerations. If water pockets are formed under large aggregate particles or reinforcing bars the concrete may bleed water and evaporate faster than the bleeding rate. Therefore, a scum of fine particles may be carried to the top of the slab creating a weak and non-durable surface which will be prone to dusting. Also, to deliver and store the goods inside the warehouse, fork-lift trucks were used requiring a smooth and flat surface. The client selected a type of floor with little tolerance which after the completion of the project became very bumpy and difficult for the safe operation of the fork-lift trucks.

At the beginning of the project the client decided to not have any permanent representation on site and to rely on the visiting architect to monitor the contract, but just before the start of the work on mechanical and electrical services, he decided to appoint his warehouse manager to the site as the project manager to supervise the last stage of the contract. This shift of responsibility for the site activities created confused lines of communication and was unwelcomed by the main contractor. The project environment was considered as complex mainly due to meeting the 34 weeks target and incorporating all the variations and changes within that tight programme.

The subcontractors were engaged in diverse activities and required planning and careful supervision to bring together their contributions in a co-ordinated manner. This did not create any difficulties in the relationship between the contractor and the subcontractors, particularly in the area of supervision of quality of workmanship. The contractor experienced adverse relations with the client due to his constant intervention in the project and not allowing an adequate management continuity in making decisions and responding to queries. The project environment was considered as being hostile since the site was located in an open area on top of a marshland where the ground was very wet and spongy, and wind was very brisk dictating the speed at which the roof was constructed. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and hostile conditions.

Case Study 4

The management contractor involvement as part of the project team began at an early stage interlinking the preconstruction and construction phases of the project and arranging the activities to provide maximum flexibility in interleaving the client's requirements. Work commenced before the design process was completed and since the design was a continuous process, management and planning expertise had to be directed to take into consideration many changes that were introduced at various stages of the project. Apart from several general updates and revisions to packages, there were many amendments to the master programme including the omissions of three packages and the addition of eight to produce the total of forty-six packages. Although the project encountered delays and required resequencing to suit the accelerated programme, the management structure and techniques remained unaltered.

Among the main project goals specified by the client was the maximum employment from the local labour force, and the management contractor had to make sure that he was consistently meeting this objective without encountering any labour shortages.

There were numerous interfaces between multiple disciplines resulting in extensive co-ordination requirements and integration of diverse activities among the fifty-eight subcontractors. In dividing the work into packages, it was intended to reduce the scope and responsibility of individual sub-units to manageable size, but also avoid high fragmentation of functional units which could have created confusion and inconsistency of goals across various units.

Due to the size of the project, many people had to be transferred from other area offices to fulfil the organisational requirements in terms of the type and number of personnel. However, there were still inadequacies such as the amount of technical advice available to the site organisation. It was suggested that if a similar project was to be undertaken again, a staff function would be required as an assistant planner to administer the drawings issues, and also an increase in the number of construction supervisors. The difficulties encountered in control and planning which needed a great deal of anticipation produced a complex environment.

The subcontractors generally performed well although the prolonged wet weather throughout the whole of the first seven months of the construction activities made the programme susceptible to delays. This effect was not repeated with the improvement in the weather conditions. One of the advantages of management contracting was assumed to be the lack of separation between the designers and the producers which would bring about a more co-operative atmosphere in which to work. However, the client introduced a slightly different arrangement in which he had the contracts manager and the county architect as his project managers jointly responsible for management of design and co-ordination and management of construction. The client required separate monthly reports, outlining all the aspects of the project including the progress, to be prepared by both project managers. In preparing the reports there was very little consultation between the contract manager and the county architect and there were conflicts due to differences in setting out priorities. Sharing responsibilities in managing the project also created confusion for the management contractor concerning how much liability he should undertake in respect to the subcontractors. The management contractor had difficulty in convincing the architect that certain problems required an immediate solution. The conflicts persisted until the completion of the project causing a hostile environment. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, complex and hostile conditions.

Case Study 5

The client wanted a speculative office development to meet the many planning and statutory control requirements of a sensitive central urban environment. The contractor believed that the client's professional adviser failed to formulate the client's design requirements and this at the outset led to delays and increased costs. However, due to the speculative nature of the project, the client had identified timely completion and cost control as major objectives which had to be closely monitored by his representative (the architect). In order to comply with these priorities the contractor explored the scope for more parallel working but this had to be limited due to lack of space and congestion. Due to the deteriorated condition of the building structure and congestion, the main contractor gave high priority to the safety aspect of the operation, and his safety officers inspected the site once every month and prepared a short report for the attention of the contracts manager. Fire regulations were a particular problem and fire officers did not accept all the features agreed with the building control officers. Additions and alterations made during construction extended the site time.

The project encountered many minor and major changes in client's requirements, such as addition of air conditioning unit in the basement. The changes were due to failure of the client and his design consultant to identify the needs in depth at the outset creating a dynamic environment. The labour demand was not met successfully and some of the subcontractors had to import skilled operatives; also the main contractor experienced difficulty in finding a good site manager after the start of the project. The economic climate was not very favourable, since there was inflation of prices and high demands for trade specialists which contributed to cost overruns.

The client was a speculative property developer who chose a traditional arrangement for organising the project, since he was experienced and understood the system well enough to direct the project. However, he appointed an architect to be his principal adviser to design the building, co-ordinate the contributions of other design consultants, and supervise the work of the main contractor. The architect kept a close eye on the progress of the work, and the client chose not to take an active part in the management of the project. This created an ineffective interaction between the client and the designer which slowed down the final acceptance of completed designs for each section of the work.

The main contractor relied extensively on subcontractors to do 100 per cent of the job, and employed 30 subcontractors in total. The subcontracts were placed under the name of the main contractor but their final accounts required the approval of the client, and the responsibility of co-ordination of the design work of the subcontractors rested with the architect. Although the employment of subcontractors has become more widespread in recent works of the main contractor, there were examples of delays in the construction stage associated with poor co-ordination of different trades on site.

The detailed programme for the project was drawn up by the main contractor and the principal adviser on the basis of the deadlines for completion set by the client. However, there were many changes to the programme due to congestion and failure in pursuing several activities in parallel and due to lack of experience on behalf of the site manager in co-ordinating and monitoring the progress of subcontractors. The client's architect took an active interest in the progress of the job on site by making regular visits and ensuring that he is accessible to answer queries, but the architect failed to keep a proper flow of finalised working drawings to the project.

The involvement of other external parties was of importance and the source of delay during construction. The building regulations apply to new construction and alterations were administered by the council and covered structural fire safety requirements, and means of escape from the building. The Fire Precautions Act provided the fire certificates covering such matters as means of escape to be issued for premises and issuing the certificate for the completed building before it is occupied. The differences between the two statutory procedures was not always understood and programme was disrupted because proper account was not taken during the design stage of the fire prevention requirements. There were some difficulties with statutory undertakers supplying gas, water, electricity and drainage which also affected the progress of the job. The local council and local tenants association co-operated fully in matters relating to the noise pollution limits and removal of waste from the site.

The project was located in a well built urban area typical of most of the main contractor's project locations. The site activities encountered congestions due to lack of space to work and lack of access to the site including no storage area. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, complex and hostile conditions.

Case Study 6

The resident engineer and his staff, representing the client on site, were mainly concerned with the time and cost of the project and together with the project manager produced monthly reports relating to the financial and physical progress of the work (the range of items discussed in this report can be listed if it seems necessary). However, the client at the outset of the project did not put any emphasis on project goals, such as safety and reliability, schedule for completion, cost control, quality control, and industrial relations, to alter the contractor's standard procedures on the site. The contractor usually gives high priority to the safety and quality assurance and on this occasion there were monthly joint visits by the contractor's safety officer and county council safety officer to inspect and comment on general site safety and more specifically on improvements to scaffold. The client regularly tested the construction materials whose results would then be compared with the tests done by corresponding subcontractor.

The project did not encounter any change in objectives and there were minor variations on behalf of the client concerning the street signs, the treatment for internal finishes for subways, and the depth of the drainage. In that part of the country there is a shortage of skilled civil engineering workers, but the work was subcontracted and the labour demand was met successfully by importing them.

The management of subcontractors was done very well since the main contractor had previous experience in co-ordinating and monitoring the work of the same group in many other similar jobs. In order to meet the basic requirements for the delivery of the project the client created an effective mechanism for bringing together a wide range of design, construction and other specialists and was successful in doing so due to his high level of project experience. The client policy was to keep flexible relationships in order to keep options open on appropriate design and construction solutions. However, the client also maintained a high level of project control by asking the contractor and his site staff to produce a comprehensive monthly report covering all the aspects of the work during that month. The programming and control of the project did not cause any major problems since the type of work was categorised as routine by the contractor.

The involvement of other external parties were negligible and in most cases the client would intervene as a buffer to protect the project team from any external impact of outside organisations. However, one case was significant and that was no structural work was allowed to be undertaken on one of the road bridges due to effective occupation of the area by Southern Gas Board contractors. The existing 16" gas main through the bridge site had to be put out of commission before the excavation of the abutment could be recommended by the Gas Board.

There were no adverse relations between the parties and generally a good working relationship existed with all members of the resident engineers staff. The only problem was the frequent visits and instructions by the client's quality assurance officers. The project location was at a hospitable environment near a well developed region, therefore transport and access to the site was good. Since the work began in October, very soon after the weather became unexpectedly bad and created delays in the earthwork operations; however, for the rest of the period during the project the weather conditions were within expectations. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, simple and friendly conditions.

Case Study 7

The project environment was considered to be stable and the only destabilising aspect of the work was to adjust the pace of the construction to the pace of the revised programme. The revision of the programme became necessary in the 15th week since the work by that time had fallen three weeks behind schedule due to the unforeseen difficulties encountered in extending the entrance foyer to the sales area. The steel frame of the foyer had badly deteriorated in certain parts and required bridge beams to augment the structure. It was decided to accelerate the work to meet the new targets and to re-schedule the input of subcontractors so that they could continuously work both during days and nights. This required a detailed programme to reorganise the accelerated work and required the motivation of subcontractors to adopt to the faster pace and the idea of new dates for completion of different packages. However, that worrying period did not cause the alteration of the management structure and techniques to suit the revised programme. The client's main priority was to have a fast completion time and this had a particular relevance since the work had to be done in live business premises when the client's business had to be maintained. The accelerated programme overcame the delays and by the start of the second section of the contract the programme was on time.

There were no major additional costs arising from cost escalation and the minor elements were largely reimbursed under a contract price fluctuation clause in the contract.

The project benefited from adequate site planning which provided a valuable form of management control enabling correct remedial actions to be taken for various shortfalls. However, since a large portion of the contract was handled by subcontractors their co-ordination had the most far-reaching effect on the overall construction time. The need to accelerate and revise the programme created difficulties in supervising and bringing together the inputs of various diverse subcontractors. Specifically the difficulty was in controlling and agreeing on a set of quality standards to be achieved during the accelerated phase. In the view of the contract manager the environmental complexity was very little and did not exert its primary influence on organisational structure and there was no need to develop specialised knowledge to deal with specific environmental elements.

The project environment was hostile and at the early stages of the project the contract manager had to make difficult on-site decisions concerning the unfavourable weather which affected the day-to-day planning of the work. In particular, the untimely delivery of materials, the risk of dangerous working conditions and damage to stored materials created many concerns.

Initially, the relationship between the main contractor and the client was friendly, but attitudes became aggressive when delays were encountered and later when the job was near to finish the behaviours turned formal. In order to deal with the unnecessary interferences on behalf of the client, the contract manager had to spend more time in the office and therefore allowed his team to make the most of the site decisions. The involvement of the local authorities and their strict monitoring of the noise pollution and the disposal of waste, since the superstore was located in a densely populated area, was considered as another cause of hostility. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, simple and hostile conditions.

Case Study 8

Due to the diverse nature of the contracts undertaken by the main contractor, there is not a single body of knowledge that can be programmed to predict in considerable detail the varying project situations or the overall behaviour of the project team in performing their tasks. Therefore, programme and programme execution is contingent on certain changing factors and characteristics of the situation and cannot easily be standardised. In the view of the site manager the construction projects always experience lack of stability in terms of their environment. However, some factors that in this research are considered as a measure of stability or the lack of it, were not taken fully into consideration since it was too early in the project to make any assessment in relation to future events. For example, it was impossible to accurately forecast the possible introduction of any alteration or modification of the design or the quantity of the works as shown by the contract drawings. However, the site manager was confident in expecting to encounter labour shortages at the peak of the operation, since the prison site was located in the countryside in the south-east of England within 6 miles radius from the nearest town.

The client's priorities were very well defined and the emphasis was placed on building the prison efficiently and quickly to a high standard. The formal planning and control procedures were undertaken beyond those carried out at the regional office and was complemented by site planning to effectively detect the deviations and to incorporate changes. Also, as part of the overall process of management, the main contractor had developed working procedures and formalised the processes involved in executing the client's order of contract which provided a systematic approach to managing quality. There were sufficient input of management resources to co-ordinate the activities of the subcontractors and it was anticipated that even at the peak of the operation the amount of co-ordination required would not complicate the management structure.

The major goals had been clearly identified for all the involved parties and the possibility that during the construction phase different interpretations of the goals might be encountered to impinge on the behaviour of the organisation were minimal. To maintain a stable condition the contract manager's and the site manager's efforts were consciously directed toward resolving both individual and interorganisational conflicts by proposing solutions that satisfied the shared criteria. Due to the tendencies of the management to resolve conflict and avoid disruptive differences, the main contractor was able to create a friendly working relationship with the client's agent. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, simple and friendly conditions.

Case Study 9

The variability and increase in costs of materials and services over the duration of the contract produced a volatile escalation in the tender prices and made the management of subcontract cost control more difficult. There were minor variations to the work defined in the contract but the progress was kept up to the original programme and the changes did not have any serious impact on the brief or the client's requirements for early completion.

The labour requirements were not determined at the overall planning stage but it was clear that in order to maintain progress the actual manpower had to meet the required strength by the contractors. The location of the site in the rural area and the fact that the contracts were mostly short-term in nature created difficulties for the operatives to find suitable lodgings within reasonable distances which consequently created recruitment problems. The project environment was assessed as dynamic.

It was believed that the management contract gave the project flexibility in terms of replanning and reprogramming whilst the design team were incorporating the revisions and by allowing renegotiation of contract periods in certain cases where agreements to enter into acceleration had to be made. Also, whilst the PSA retained the overall responsibility of cost control, the management contractor provided valuable advice on comparative costs of alternative construction techniques during the detail design stage. However, due to the sheer size of the project and the emphasis of the client on timely completion, the process of breaking down the work into many separate contracts, where each required competitive tender, site supervision and valuation, and final account action became complicated especially at the peak of the operation. In order to overcome this problem, in the post-contract stages the PSA and management contractor quantity surveyor resources were combined and individual responsibilities for cost control and final account action were allocated with a management framework that recognised that on matters of subcontract control and progress the management contractor would be the initial focal point whereas dealings and agreements on matters of valuation and final account would be with the PSA.

The project encountered adverse weather conditions during the first half of the contract and the forecasting services were of particular assistance during that period. Arrangements were made for the regular supply of simple forecasts by telephone to the site office to help the day-to-day planning of the work. However, the adverse conditions hindered the timely delivery of materials, caused some damage to newly poured concrete and increased the risk of dangerous working conditions on the site.

The management contractor was not exempt from complying with the codes of statutory regulations especially relating to the mechanical plant operation which received regular inspections. The project manager knew of his responsibilities under the construction regulations and ensured that they were complied with by all the employees on the site. There was no conflict between the client and the management contractor and all the parties attempted to avoid disputes and resolve problems by negotiation. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, simple and friendly conditions.

Case Study 10

The client had identified cost control as the most important objective and required the contractor to minimise cost within the time constraints imposed by the contractual completion date. The desired objective was mostly achieved by manipulating labour and plant in such a way that time-related costs for these common resources remained near to constant, and that was helped by the lack of any noticeable increase in the inflation to outstrip the subcontract tender prices. However, the introduction of variations to the works contributed to the additional cost of 4 per cent in the total tender value, and any other cost increase was mainly due to the unforeseen ground conditions which required a cautionary approach to excavation and extra foundation support systems.

The contributions of the support staff including the planners in gathering information on project execution progress and providing realistic estimates relating to the future operations helped the project team to predict and think systematically about the activities and their integration, thus creating a stable environment.

During the overall planning stage it was realised that a great deal of information was necessary to control and co-ordinate the arrival and progress of the subcontractors to avoid any confusion and delay since the site was congested and the access was inadequate. In order to have the co-operation of subcontractors and to create a good site relationship, the subcontractors were contracted at least two weeks before they were due on the site and were consulted when drawing up the short-term programmes to agree on the schedule and the call up time. Schedules for material deliveries were drawn up at the overall planning stage and frequent checks were made on the short-term plans to ensure that the hold-ups were avoided and the non-arrivals were kept to an absolute minimum. Delivery times did not allow for much flexibility since the site lacked enough storage space, and therefore immediate actions were required if materials did not arrive as scheduled. The short-term programmes were used as the basis for controlling progress of the subcontractors and they were discussed at the site meetings to get the work back on the programme.

The project environment was complex, partly attributable to the project manager's refusal to consider the main contractor's recommendations on the buildability aspects of designs and partly to inadequate monitoring of the design information flow and obtaining timely design approvals from the client.

Co-operation between the project manager and the planning engineers was required to facilitate an effective planning process and to manage the co-ordination and information gathering systems. However, a fundamental difference in their attitudes was a cause of continuous conflict. The planner's orientation was long-range inducing him to integrate the future activities and thinking systematically about the routine operations, but the project manager's orientation was short-range seeking immediate solutions without considering the implications. The main contractor relied on sympathetic responses to problems and took a series of actions to mitigate the effects on the overall progress. In similar cases the main contractor would operate the procedures in the contract more rigidly. However, exceptions to this, where lack of decisions could have affected the progress of the work, were considered acceptable. In the view of the main contractor his efforts and the variations were not correctly valued and therefore a serious dispute was resulted which was referred to arbitration.

Apart from the adverse relations between the project manager and the main contractor, the restricted delivery times imposed by the Highway Department and the complaints to the Council's health officers by the local residents for the reduction in the noise level contributed to a hostile environment. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and hostile conditions.

Case Study 11

The main contractor's involvement was limited only to the post-contract period, and therefore constructability was not enhanced due to lack of solicitation and implementation of his preferences relating to the layout, design, and the selection of permanent materials. The early identification of the preferences and their effective treatment, the initial issues of drawings and specifications would have resulted in minimal design breakages. However, the contractor's anticipation of remedial tactics and variations prepared him to accept the accommodation of any change in response to actual field problems.

The selection of the subcontractors and the execution of the work were highly influenced by the market forces which under the prevailing economic situation were unpredictable and unfavourable. For example, the lift manufacturers were not able to fulfil the demands and had to increase the lead time from 15 weeks to 30 weeks with a price rise of up to 10 per cent. Although the shortage of skilled operatives was not significant, but the availability of skilled managers within the contractor's organisation lacked compatibility with the site requirements. Based on the experience of the construction manager during the early part of the programme, the project environment was relatively unstable.

The decision to follow a particular contract strategy and enter direct negotiations with a local contractor created a greater expectation and committed the contractor to ensure that costs were kept within the budget and the urgency for completion was adequately met. However, this arrangement promoted a process which required a tripartite agreement between the architect, the quantity surveyor and the contractor in making decisions. This approach contributed to conflict and delays that could have been avoided if a centralised system, where the architect could convey the client's requirements by timely and clear instructions, was adopted.

The party wall agreements drawn up by the adjacent building owners to set the conditions for construction of the new residential block showed little tolerance of the site activities. The use of pneumatic drilling devices had to be limited to the hours between 11.00 am and 2.00 pm and the compressors had to be silenced to cut down the noise nuisance. The complexity in the environment was also due to the difficulties encountered during the negotiations in order to draw up the agreements based on what was defined and accepted as reasonable.

The environmental officers regularly inspected the site to ensure that the contractor was complying with the pollution act concerning the collection and removal of waste, the level of dust and the level of noise during working hours. The site had severe problems with deliveries and cart-away rubbish since it was located in a residential area with inconvenient access. Meetings had to be held with the local residents and approvals had to be obtained from the local authority, fire brigade and police to close the street to through traffic for short intervals. Also, permission had to be obtained from the Highway Department for the use of the pavement and the suspension of parking meters and parking spaces for the delivery of materials and off-loading, and for supporting and sheet-piling the street during the excavation and substructure activities. The relationship between the contractor and the party wall surveyor was of a hostile nature, but the conflicts were resolved by setting up formal procedures for inspection, instruction and action by relevant parties. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, complex and hostile conditions.

Case Study 12

The London Dockland Development Corporation, being the planning authority, paid special attention to the design of the facade and the selection of building materials. However, the planning committee was unable to decide on the type of materials and ultimately delayed the production of detailed design and limited the amount of overlapping to achieve a fast project. Also, due to the uncertainty of the tenant concerning the fabric and the services in the retailing department, it was agreed to delay the design and only retain the client's original scope to the building entrance and the shop-front to generate a common overall pattern, whilst allowing the tenant individuality in terms of signwriting and display.

The project objective of speedy construction did not eliminate flexibility in accommodating a reasonable number of design variations, but the changes in the client's requirements were many and deviations from the construction of the work as planned were introduced for operational reasons. The rapid introduction of variations caused a dynamic environment which had immediate effects such as the need to increase the number of quantity surveyors present on the site to deal more effectively with the additions in the volume of the work.

The project was not considered to be complex and the contractor's understanding of construction matters did not require a fresh approach or attitude towards the management and running of the contract, except that the contractor was very conscious of the need to minimise disturbances to early occupiers and planned the construction operation for phased completion and hand-overs.

At the early stages of the project remedial actions were required and schedules were reproduced to keep the progress up to the original programme, since the time for the receipt of bids from subcontractors was extended and needed five weeks to get the tenders back. Although the environment was considered as simple, the control of the progress was essential and entailed the production of programmes, method statements and other planning information including the breakdown of activities in much more detail allowing finer control to be exercised.

The project manager showed an understanding of the importance of timely, rather than exclusively, cost-based decisions and as a result no discord was experienced by the involved parties. There was no need to cut down the noise nuisance, especially from the piling work, since the surrounding building developments had not been completed for occupants and the local residents were not within close enough proximity to file complaints with the Council health officer. Fire escape and fire resistance standards were strictly imposed by the fire authority officers making sure the building conformed to regulations. Adjacent to the site there was a deep reservoir of water with a depth of 12 metres which was planned to be converted into a fishing pond after the completion of the construction activities. The London Dockland Development Corporation representatives made occasional inspections to check whether any waste had been disposed of into the reservoir. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, simple and friendly conditions.

Case Study 13

Due to adverse weather conditions and for climatic reasons the subcontractor failed to achieve the target date for the completion of the carriageway surfacing and therefore the chances of opening the new road to traffic by the contract date was severely jeopardised. In order to meet the requirements for sectional completion including the completion of mechanical and electrical installations, the programme network was updated and revised several times to interface these operations with the fast-moving roadworks activities during the latter stages of the project. The main design concepts and objectives were set out to produce design solutions to deal adequately with the complex technical problems encountered along the route and to minimise environmental effects and disruptions both in terms of the construction process and the completed scheme and to produce a total design concept absorbing the road within the rural environment. Although the main design objectives remained intact, there were many detailed variations that altered the construction methods and resulted in a dynamic work environment.

The policy of the Department of Transport was to require the main contractor to be responsible for locating and supplying materials to the site in compliance with the specifications. In view of the potential scarcity of suitable fill and gravel materials, this policy allowed the main contractor to search for the right materials and pursue the combination of two options which were to obtain planning permission for deepening or extending the existing pits in the near vicinity of the site, and to import material by road from sites where existing permissions were extant. Difficulties were encountered in obtaining the planning permission, since the authorities were concerned that excavation for such large quantities would add significantly to the environmental damage, and therefore the main contractor in order to satisfy the majority of requirements had to import materials which were more expensive and led to heavy traffic on the existing road system both at the source and at the site.

In defining phase completion dates and the associated commissioning and testing phases for the mechanical and electrical works, little tolerance was introduced into the interrelated programmes, and the progress of the civil works and the subsequent commencement and completion of the services installation created interface problems and required careful monitoring and close liaison between the principal contractors and the client's project team.

The area was ideal for a straightforward road and tunnel construction, but for control and security reasons it was decided to establish the site office on the west side and immediately adjacent to and approximately at the centre of the site, so that it could be used as the main access for all personnel, plant and materials entering the site. Hence, the access was limited to one point of entry. Although the site access and the construction process were designed to ensure minimum disruption, traffic management was still a serious problem. The co-operation of the local authority and the police was fundamental to the success of the project and their helpful assistance reduced the problem associated with traffic control to a manageable proportion, although some night-time occupation, when one or other of the carriageways was closed, was unavoidable.

Some constraints were encountered in the tunnelling operation, since the tunnel route was near an existing British Rail tunnel, and thus blasting was carefully monitored by British Rail and was restricted to one blast per day between rail services. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, complex and friendly conditions.

Case Study 14

There had been a number of site investigations within the boundaries of the airport associated with the expansion scheme, and the development which included a preliminary ground investigation on a broad scale followed by a comprehensive main ground investigation that supplemented the findings of the previous work with particular reference to the locations of the new structures. The earthwork activities revealed that conditions were those implied by the studies.

The general design principles remained unchanged and there was little modification of the design and quality of the work as indicated by the contract drawings and described by the contract bills. It was essential to arrange from the beginning an agreed procedure to deal with variations and instructions so that the work could be carried out in accordance with the programme requirements which subsequently brought about a stable environment throughout the life of the project.

To promote effective communication and consistency of approach the management contractor's three departments namely Building, Civil Engineering, and Mechanical and Electrical Engineering were set up as the principal production departments, taking overall responsibility for the contractor's site administration and providing specialist backup services to the project teams including the client and the design consultants. Progress monitoring played an integral part in planning and while the basic data was gathered by the various production departments, the data was all efficiently co-ordinated and reported by the planning department. The administration of the drawing registry system was computer aided and was undertaken on site producing a large number of prints a day during the peak times.

The effective cost control was considered to be of prime importance and to ensure that the client was kept informed of the anticipated final cost and the anticipated level of monthly expenditure, formally distributed progress reports were produced monthly by the civil engineering contractor and included status and trend reports on construction.

The only means of reaching the construction area was through a narrow temporary access road which was essentially an airside road within the airport security fence boundary for use by aircraft tugs, baggage handling dollies and buses. This road was not sufficiently adequate to provide access for all the contractors involved in scheme. The airport's ground was of boulder clay, and while stiffer and easier to work with than the London clay, it was sensitive to wet weather since the presence of a large amount of chalk tended to hold water and hamper the excavation during the prolonged rainy season. The development attracted staff at the expense of the local industry, and although the general employment situation of the area benefited and the effect on housing demand by workers moving into the area was slight and was spread over a wide region, the development faced a hostile reaction from the surrounding neighbourhood. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, simple and hostile conditions.

Case Study 15

The main contractor was not involved in the development of the scheme content and there was a lack of opportunity during the tender stage for detailed intercourse to establish improved method of construction. After award of contract, studies by engineers prior to mobilisation resulted in some adjustments to the methods. For example, a short study was conducted to develop a mechanised technique for removing and replacing welds on the longitudinal butt joints to the deck plates and bottom horizontal plates. The main contractor had to receive approvals for each individual section of the project and had to comply with the written proposals from the client concerning the construction methods. The client did not have permanent site representation and was unaware of the details of the operations and some of the obstacles. Nevertheless the fl;ow of work and the anticipated methods of construction were frequently interrupted by the revisions. Although there were frequent changes in construction methods the amount of design variations was very little and amounted to only about 2 per cent of the total contract value. The main contractor practices short-term planning for detailed activities of each month. However, due to availability of information and the time invested prior to the onset of construction, the overall plan did not change which was the main contributing factor to the environmental stability. Also, the project goals and priorities expressed by the client remained unchanged throughout the project.

The execution of the project required a great deal of effort and skill since the operation had to cope with the constraints imposed by the Avon County Council concerning the traffic flow and the fact that the bridge had to remain open during the project. A work study was conducted to find an access to the bridge and to devise a delivery method and schedule of work for different trades. Due to the strategic location of the infrastructure the site was closely guarded and the Police provided a tight security which created more access restrictions.

Due to environmental conditions the supervision of safety standards became an important and difficult task. A safety officer was appointed to the site and made regular reports to the head-office and arranged regular meetings with the site members to brief the organisation about the safety requirements. Two safety films were shown in the early days of the contract and no opportunity was lost in emphasising the importance of taking all possible safety precautions. Proper gangways and means of access were included in all designs of temporary works and a safety boat was always in attendance in the river with an inflatable raft for use at low tide. Another major concern was the safety of operational use of temporary structures, such as the travelling gantries which were fabricated on site and erected to obtain access below the suspended structure, that were moved as part of the system. All moving structures had operational constraints that were derived from consideration of environmental forces affecting control and stability.

The special requirements in relation to various statutory authorities introduced restrictions on commencing work or moving heavy plant and equipment over any portion of the site. The main contractor had to ensure that the British Telecommunications plant was protected from any damage and prior to any work the presence of hidden plant had to be indicated by markers under the supervision of the British

Telecommunications representative. The Central Electricity Generating Board and the Area Electricity Boards provided documents specifying the requirements of Health and Safety Executive Guidance and recommended avoidance of danger from underground and overhead electricity cables. The main contractor required from time to time to be allowed to take possession of the British Railways Board's land for use as route of access to the site. During the course of the project the existing navigation lights situated on the towers, piers and main spans of the Severn bridge and the Wye bridge had to remain undamaged, and the minimum navigational clearances above Ordnance Datum at mid-span of the two bridge were not to be reduced as specified by the Gloucester Harbour Trustees.

The work environment was difficult and dangerous and was governed by many factors such as the severe weather conditions and winds up to 60 miles per hour. Another example of hostility in the environment was the work on the welding of joints which generated fumes inside the box girders and required extractor fans at all working points. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and hostile conditions.

Case Study 16

The British Library, as the PSA's largest civilian project, has been subjected to detailed public scrutiny with regular parliamentary questions and announcements of cost revisions. The contractual arrangement has caused an inherent contradiction between the concept of management contracting and Treasury controls over finance, since the management contractor is not allowed to adjust priorities as circumstances demand but has to comply with annual expenditure constraints. This means that there is a time limit on spending in order to meet the targets which does not always fit in with on-site requirements. At the time of interview, a significant number of parcels were late in going to tender due to the late issue of specifications and drawings for preparation of bills of quantities. The delay for measurement purposes was reflected in the number of parcels where procurement was behind programme, and although these delays were not expected to affect the contract completion, there were considered to have a severely adverse effect on the current expenditure forecasts.

The development boom in the South-East and the overheating of the industry together with the protracted length of the project, have caused a number of tenders to go above budget, and this was expected to increase over the future months as tenders are received for the more labour-intensive mechanical and electrical contracts. The dynamic nature of the environment is also due to the lack of commitment of the client to the whole structure as it was originally envisaged and the construction programme as it was originally planned, introducing regular changes to the parcelling of the work as more detailed design information becomes available.

The British Library is given beneficial occupation of the building before the completion date, starting from the basement. The objective is to progressively fill the book stacks, starting with those from remote sites, until completion of the first phase in 1993. Loading the shelves with books is a major task, and thus the British Library has appointed its own engineer to oversee the operation on testing the shelving procedures. Also, a great deal of thought is being given to the logistics of packing and the need to stabilise the atmosphere of the building as the books introduce humidity and energy into the structure. Although it is felt that there are advantages in working through the PSA in terms of maintaining the standards and benefiting from their experience of building at all levels, the size of the Agency in terms of its organisation has created certain problems. These problems are mostly related to the cumbersome and slow operation of the large organisation, which has been partly resolved by introducing representatives from the contracts department on site to accelerate approval procedures for tenders received.

A dispute erupted between one of the main contractors and the bricklaying subcontractor which resulted in the termination of the year-old contract and expulsion from the site of 130 workers employed by the subcontractor, who had to lay over 4 million fletton bricks in the library's huge basement. The subcontractor tendered on the assumption that 450 bricks per man per day could be laid. However, the output only reached 350 bricks. The subcontractor blamed the lack of progress of the contract on the tolerance demanded by the client that was thought to be unrealistic and the site conditions that required the work to be carried out under artificial light. The main contractor considered the PSA's insistence that retarders should not be used in mortar was the cause of delay, but the management contractor saw no problem with the use of retarder providing it was properly controlled. In the view of the management contractor, the delay arose mainly from the very slow mobilisation of the bricklaying subcontractor and the knock-on effect on the following tradesmen such as the plantroom tanking and tiling, and the failure of the main contractor's site management.

Due to public accountability, the PSA has been very insistent on full competition for all tenders and requires no less than six quotes, and demands a great deal of meetings and paperwork which is considered as a cause of frustration among the site team. The influence of various stimuli on environment was interpreted by the research participant to have produced dynamic, complex and hostile conditions.

Case Study 17

In order to achieve a high level of integration among the separated managerial and technical responsibilities, a special construction manager was appointed to co-ordinate the various tasks of the professional team. Benefits were identified with the construction management approach and the negotiated contract which were associated with the greater potential for speed due to early involvement of the contractors in the design process and the overlapping of design and construction. The construction manager provided valuable input on the availability of material and labour, considered the sequence of construction so as to avoid or minimise any foreseeable obstacles and planned ahead for long lead items. The potential benefits of integrating construction expertise into the design process meant that leadership was provided in the early project phases by the construction manager who worked across functional boundaries and actively tried to minimise the co-ordination and integration problems.

A major challenge was to provide the trade contractors with the information they needed for bidding, since due to complications with the design co-ordination some drawings were not completed on time for the scheduled bid dates. However, this slippage in bid dates did not disturb and affect the original sequence of contracts and the programme. The work environment was considered as stable mainly because of a good brief which provided a set of basic requirements of the building and clearly defined its budget and programme. As the design evolved, the brief was filled out. It was also realised that it is counter-productive to begin work too early and accept variations later. Thus, the work did not begin until approximately 60 per cent of the design was completed and costed.

The client's construction director chaired a weekly director level site meeting of all the trade contractors, at which the problems were identified and resolved. The meetings also served other functions. By requiring directors to visit the site so often the project continued to get head-office back-up and attention and also kept the client in direct contact with the contractors. The client deliberately tried to keep the number of trade contractors on each phase down to around 25 rather than the 75 traditionally expected, to simplify site control and co-ordination. Many trade contractors had to build at a pace they had never experienced before and therefore required to streamline their operations and work processes. For example, in the case of the dry lining contractor, to ensure that time slots on loading bags were tight the firm collected huge amounts of plasterboard from the manufacturer directly rather than relying on deliveries. Special hydraulic equipment was used to transfer one tonne, shrink-wrapped packages of plasterboard on to trollies. The trollies acted as storage racks keeping the board off the ground and the package remained wrapped until needed, thus reducing the amount of waste of the dry liner that arrived on site. Also the fire protection contractors developed central mixing and pumping facilities for the sprayed contracts to produce a more efficient site set-up with less disruptions to other trades. Fire protection represented 10 per cent of the cost of the steel frames, and the simplification of the operation contributed to maintaining the competitiveness of structural steelwork.

Modular construction techniques were a major factor in the successful completion of the first four phases, since by removing as many wet trades as possible the systems provided a simple solution to traditional construction. Using modular systems allowed a greater standardisation of design and layout within the buildings. However, at first the client needed to be educated as to which form of building was suited to modular system.

Hostilities in the environment and interruptions in the progress of the site works were caused by external influences that originated from a wide variety of sources such as the integration of the efforts of a number of different organisations and individuals, social and environmental factors, and project location. For example, a magistrate for the City of London imposed fines on the construction manager for offences against the noise pollution laws. The notice was issued following complaints by local residents that work on site was causing noise at times outside normal hours allowed for construction in the City. To remove the problem the trade contractors were asked to use complex sound mufflers to cut down the noise nuisance from the piling works. In addition the construction management firm was fined and was ordered to pay compensations to the Corporation of London. Another source of hostility was the added technical complications of building the more massive ten later phases directly over Liverpool Street Station's operating platforms and approach tracks and working under live conditions. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and hostile conditions.

Case Study 18

Generally there were no major problems concerning the equipment delivered with the exception of work which had to be done on the surge drum. During the early part of the contract, drawings were submitted by a trade contractor for the removal of the roof section required for the installation of the fermenter vessels and surge drum. At the time of checking, the only dimensional drawings relating to the vessels were the management contractor's mechanical drawings which were the basis for the fabrication. The roof and steel drawings were checked against the mechanical drawings and an agreement was reached concerning the roof removal. No problems were encountered with the installation of the fermenter vessels since all the dimensions tied in accurately with the steelwork. However, when the surge drum arrived on site it was discovered that 300 mm wide stiffening rings had been added at 1 metre intervals. This meant that the vessel was out of dimensional tolerance for installation through the roof. The construction department had not been issued with any drawings or informed of the change. In order to install the vessel, the stiffening rings had to be cut at one arch to allow 5 mm clearance. In addition the skid units for the homogeniser and arkasoy packages were delivered late which again required some changes to the construction programme.

Clear guidelines were provided in a specification format to aid in selecting fabrication shops for plant equipment which included pressure vessels, heat exchangers, and storage tanks. Before recommending a vendor or awarding a contract the management contractor required a shop survey report to make sure that a vendor would bid with adequate shop capacity, shop equipment, and man-power. The guidelines for careful bid evaluation and shop selection minimised delays in shipment and precluded many consequential problems such as revising the programme. The stability of environment was partly due to weekly meetings that were held and attended by senior site and project personnel in order that the overall site budget and construction schedule could be established in line with the priorities identified by the client.

Early in the project, meetings were held to agree with the client the level and definition of the quality control for the construction works. The management contractor established and imposed a quality control system on the trade contractors by utilising the in-house system and existing documentations, and a filing system was set up with approximately 2,000 files which were activiated for all the disciplines and were regularly up-dated by field supervision and the relevant trade contractors. The complexity of the job required a great deal of support from the head office for procurement services, vendor drawings, and the use of micro management system for planning and cost control, and good communication to facilitate interface control with the site office. The construction activities were segregated into pre-shutdown and shutdown work, and subdivided by work area. The manpower requirements were determined according to the above segregation to allow for good site productivity and avoid labour saturation. Construction planning and execution took into consideration the main objective of minimising the disruption of plant operation during the pre-shutdown work, and the duration of plant shutdown time.

To provide accommodation for the site staff, the client decided to allocate the existing plant building and stores to the management contractor. The stores were full of materials and fittings which had been gathered there on various small projects undertaken over the intervening years since the site was opened. Some difficulty was encountered in trying to segregate an area for the materials and fittings required for the new project.

Subsequent to the contract award, the client met with the management contractor to determine industrial relations strategy for the project, which was undertaken in accordance with the National Agreement on a non-nominated basis together with other agreements as appropriate. The trade contractors were given a copy of the industrial relations policy and were interviewed by the industrial relations manager and the resident construction manager to establish the recruitment policies and procedures and the industrial relations policies. They were also required to attend an induction course which included a tape slide presentation of safety at the plant and security arrangements. The management contractor liaised very closely with the client on all industrial relations matters through the personnel director at the client's head office and established very good relationships with the local trade union officials which resulted in the completion of the project without encountering any disputes.

The management contractor built up mutual trust and respect with all the involved parties and maintained direct contact and co-ordination at all levels, but to obviate possible deviation from the contract intent, daily supervisory meetings were held at the site office. The work environment was friendly and the working relationships proved very satisfactory with the contract operating on a semi-formal basis. The influence of various stimuli on environment was interpreted by the research participant to have produced stable, complex and friendly conditions.

2.2.1 DIMENSIONS OF ENVIRONMENT - CASE STUDY FINDINGS

The case studies treated the environment as uniform along each of its three dimensions, and the research participants were asked to consider which one aspect is dominant enough to affect the entire organisation. The responses, summarized and presented in Tables 2.2.1 and 2.2.2, are based on the contracts managers interpretation of real situations encountered from the commencement of the projects up to the time of interview. This approach required a judgemental decision and a commitment to understanding the organisational phenomena from the actor's own perspective.

The statements of judgements made for each case study is translated into various combinations of 1s and 0s, Table 2.2.1, illustrating the assumed dominance of a single environmental characteristic, or the complete lack of it, in the corresponding number of case studies. The results indicate that on the stable-dynamic continuum more emphasis is placed on the stable characteristics of environment and in accordance with the hypothesis the theoretical implication is that the majority of the organisations standardised the activities of their operating cores and established rules and written manuals to formalise behaviour. The discussions also reveal an overwhelming support for dimension of complexity and thus the tendency towards decentralisation of technical and administrative decisions and the use of mutual adjustment as a co-ordinating device. On the hostile-friendly continuum the emphasis is on the hostility of environment resulting in temporary centralisation of structure and greater reliance on direct supervision.

Case Study Results, Table 2.2.1

Case Studies

Dimensions of Environment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Stable	1	1	1	0	0	1	1	0	0	1	0	0	0	1	1	0	1	1	10
Dynamic	0	0	0	1	1	0	0	1	1	0	1	1	1	0	0	1	0	0	8
Simple	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	0	0	0	6
Complex	1	1	1	1	1	0	0	0	0	1	1	0	1	0	1	1	1	1	12
Friendly	1	1	0	0	0	1	1	0	1	0	0	1	1	0	0	0	0	1	8
Hostile	0	0	1	1	1	0	0	1	0	1	1	0	0	1	1	1	1	0	10

1 indicates total compliance with the corresponding dimension
0 indicates non-compliance with the corresponding dimension

Dimensions of Environment, Table 2.2.2

Dimensions of Environment		Prime Structural Characteristics
Stable (56%)	:	Insulate and standardise the activities of the operating core; establish rules and written manuals to formalise behaviour; greater use of action planning; achieve as precise an ordering of functions as possible to bring about regularity and predictability.
Dynamic (44%)	:	To coordinate different parts of organisation the need for continuing communication is correspondingly increased; reduction in the use of rigid procedures and job specifications resulting in a lesser bureaucratic control; reliance on more flexible and less formalised coordination mechanisms.
Complex (67%)	:	Decentralisation of technical and administrative decisions especially among the professionals of the operating core; the use of mutual adjustment as a coordinating device.
Simple (33%)	:	The coordination is achieved by centralisation since there is no problem of comprehensibility to require the delegation of administrative or operating decisions among various units.
Hostile (56%)	:	An immediate but temporary centralisation of structure and greater reliance on direct supervision for tightest means of control.
Friendly (44%)	:	There is no requirement for temporary or selective centralisation in vertical or horizontal dimensions to protect the organisation from external influences.

2.3 DIMENSIONS OF TECHNOLOGY

Technology is a major factor in the design of organisational structures and is primarily a phenomenon influencing three components of structure; the middle line, the technostructure, and the operating core. However, the definition of technology is not always very clear and in order to operationalise this key independent variable, we categorise it into three dimensions and present three basic hypotheses, drawn from the integration of various streams of literature concerning the relationship between the structure and three dimensions of uncertainty, complexity and interdependency. Prior to presenting the hypotheses, the impact of these dimensions on structure is briefly discussed and later in the chapter compared with the actual data to evaluate the accuracy of the theoretical suggestions and hence to test the hypotheses and to state in terms of continuous relationships, when taken together with the dimensions of environment, the specific types of structures they generate.

The dimension of uncertainty is measured by the intermediate variables of predictability of work activities and variability of work items reflecting the prior knowledge of the organisation concerning the work. As the technological certainty increases the technical system becomes more regulating and consequently the work activities become more routine and predictable, lending itself to standardisation of skills and processes. The control is more formalised and impersonal and the structure more bureaucratic. Due to predictability of the system the support staff in the technostructure can produce detail plans early in the life of the project and design work flows, and thus become more involved in the supervision of the operation indicating a shift of power and decentralisation of authority in the horizontal dimension. In a non-regulating system control of the operating work remains with the skilled operatives of the operating core and their direct supervisors producing an organic structure.

The dimension of complexity, reflecting the sophistication of the technical system, is measured through the intermediate variables of comprehensibility of the work concerning the ease with which the work of the organisation can be understood, the use of unfamiliar design standards or construction methods, and the number of simultaneous work activities. These variables increase the reliance of organisation on functional specialisation for decision making, and consequently promote the support units and decentralise selectively where the technical experts are found. Furthermore, this reliance will affect the proportioning of administrative intensity, because allocation of responsibilities to professionals in technical fields alters the amount of co-ordination and results in a higher administrative ratio for the construction team. In a complex organisation, one can expect to see multiple differentiation in its operating system; that is, the greater the number of differentiated sub-units, the greater the complexity of the organisation. In order for the organisation to tolerate this structural differentiation it requires an elaborate administrative structure and task forces and other liaison devices to make decisions and co-ordinate decision making processes.

Interdependency in an organisation exists at many levels and it is an indicator of the extent to which work processes are interrelated such that changes in one affect the state of others. This study concentrates on two broad levels of interdependence between tasks and between organisational subsystems and functions, since it has been suggested that at task level task interdependence is a differentiating factor and at organisational subsystems interdependence is an integrating factor.

Thompson (1967) has discussed the way in which interdependence constrains structure, since he posited that there are distinct parallels between the three types of interdependence and the three types of co-ordination. Interdependence may be pooled (each part renders a discrete contribution to the whole and each is supported by the whole), sequential (direct interdependence and the order of that can be specified), or reciprocal (the outputs of each become the inputs for the others). Pooled coupling involves the least amount of interdependence between members and because of the natural characteristics and end-oriented nature of building projects it is encountered infrequently in the organisation. Tavistock (1966) has pointed out that the building process is characterised at its formal level by a preference for sequential interdependence. Reciprocal interdependence is extensive between parties within the design and the construction subsystems depending upon the degree of overlap and the nature of the interface. The above interdependencies affect the type of co-ordination in such a way that one may expect co-ordination by standardisation for pooled interdependence, by plan and establishments of schedules for sequential interdependence, and by mutual adjustment for reciprocal interdependence.

The lack of spacial distance and close physical proximity and the need to couple their activities, the organisational members are frequently engaged in informal communication which in turn encourages co-ordination by mutual adjustment. In fact, it may be hypothesised that on a building project, especially where there is reciprocal interdependence in a multi-group situation, there will be mutual adjustment by committees or liaison groups. The involvement of different trade specialists in a project would require a greater amount of horizontal decentralisation for the purpose of smoothing the path for co-ordination by mutual adjustment, and vertical decentralisation so that the activities of each unit are supervised by one manager probably from the same trade.

The dimension of interdependency is measured by the degree of physical congestion and the consequent delays, the degree of mechanisation, the degree to which resources are shared, and by the distinguishable successional number of phases in the construction process.

In the following paragraphs, three hypotheses concerning the effects of dimensions of technology on organisational structure are presented and complimented by discussions to determine the effective dimensions of technology for each case.

Hypothesis T1: As the technical system becomes more regulating the execution of work becomes more routine and predictable, and therefore the organisation tends to rely more on impersonal methods of control such as formalisation and specialisation. This hypothesis deals with the concept of uncertainty among technological functions and is measured by variability of work items and predictability of work activities influencing the characteristics of procedures for planning and control.

Hypothesis T2: As the technical system becomes more complex, there is more decentralisation of structure and greater reliance on support staff. This hypothesis relates to the dimension of complexity and is measured by the comprehensibility of the work, the number of simultaneous work activities, and the use of unfamiliar design features and work methods.

Hypothesis T3: The more interdependent the range of activities, the more decentralisation of decisions and greater functional specialisation. This hypothesis refers to the degree of interdependencies and the extent to which work processes are interrelated such that changes in one affect the state of others.

Case Study 1

Although detailed design was not completed before the start of construction, the client avoided changes to major objectives which made the project more predictable, preventing major revisions in design and programme. Design decisions were based upon good predictions of site conditions, the availability of materials, the use of special services, and the availability of labour, since definite information on these were obtained beforehand. The client was successful in defining the authority and responsibilities for design and construction of all stages at the start of the project reducing much of the confusions caused by differences in their objectives, knowledge and experience. For example, the responsibilities for detailed designing were removed from the engineering consultants and given to subcontractors for their greater specialisation in certain materials and techniques.

The client's project team expressed no particular preference for the method of programming, and the main contractor practiced the usual methods such as the network analysis for sequencing the activities and barchart for presentation reasons and for packaging the subcontractors portions of work. The updating and resequencing of work activities to meet schedule requirements was considered as an on-going procedure for minor items with little impact on the completion targets.

One of the significant causes of uncertainty was the lack of adequate presentation of information by subcontractors relating to their progress on the project and submitting late reports to the section managers. As evaluated by the contracts manager all the contributing elements were in operation to make the project as predictable as possible, hence experiencing very little uncertainty.

The frequent and full communication between the client's representatives and the main contractor helped them interact effectively and speeded up the final acceptance of the completed design, and although the contributions of a number of specialists were built in at the early stages of design, still the contracts manager rates this project as the most complex one he has ever managed. Several of the design and construction techniques were unfamiliar to the contracts manager, specially in the areas of services and curtain walling.

The design of the building included curtain walling made on panel system with mechanical fixings, and as a special feature in certain areas of the building a rain-screen/air barrier approach was used to give the client the air-sealed building he wants. This approach involves using the outer skin of the building as a rain-screen only, allowing air and moisture to penetrate avoiding the creation of pressure differentials. The inner skin then acts as the air barrier, creating the building's air seal. The glass being used on the building is blue, and although it is reflective from the outside and reduces solar glare, it looks almost colourless from the inside. The reflective blue glazing minimises the degree of cooling needed in a highly serviced building.

The building services design was split between the mechanical and electrical services. On the mechanical side, the building has a Vav system with perimeter heating, and on the electrical side lighting is by uplighters and power/cabling is through cavity floors on the insistence of the client that nothing should impede the clear glazing.

The site was located close to a well-built area with good access roads and no traffic congestions which made any restrictions on the time-table for material delivery unnecessary. However, there were a great number of trade specialists and due to their work-flow interdependencies for different packages of work - for example water-proofing had to be completed on time before mechanical installation could begin - there was a need for careful monitoring of progress and co-ordination of activities on site to avoid physical congestion and help timely completion.

The development project contained two distinct phases excluding the demolishing work. They were foundation and substructure including the car park and plant rooms, and superstructure and finishing, all being divided into two main contract programmes. The functional duties of design were allocated to independent professional practices and different performance criteria at each side of the design-construction interface for each phase was in operation. The performance of construction was causally and directly linked to the output of designs, and thus the project measure of effectiveness at each interface was organisational relating to the interdependencies in flow of information and procedures. Through discussions with the contracts manager it was revealed that the amount and the extent of interdependent activities experienced in this project were greater compared with the similar projects managed by the same manager. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 2

A factor contributing to the uncertainty of the operation was the extent to which the client changed his requirements during the design process and more critically during the construction of both stages of the contract. The introduction of variations and the consequent escalation in the cost, mainly in terms of abortive work, did not alter the schedule targets which were very tight. Due to the large number of variations it was necessary to minimise the effects by continually and rapidly replanning the work, since by maintaining the momentum of the job and its productivity, the contractor was able to follow the intended timetable.

Design decisions and the assessment of the building characteristics were based on the contractor's previous knowledge of the design history, since it was originally designed and built by the same contractor. The responsibility of the production of detailed design and working drawings was with the corresponding subcontractors who gave effective technical input. Their involvement and responsibilities did not change hands and remained with the designated groups. The discussions with the contracts manager revealed that in his opinion the project situation was technologically uncertain.

The design was simple enabling the contractor to use readily obtainable standard materials and components to facilitate speedy construction. The contractor's expertise was brought into the process of design, since his previous involvement and knowledge abut the building ensured that the design features facilitated quick construction particularly in the case of redesigning the steel frames to support additional services. The method of construction was compatible with the design, and was broken down into a series of relatively simple operations. There was no need for the adoption of planned methods of construction or the utilisation of purpose-made equipment. The most difficult aspect of the work was the installation of mechanical and electrical services which required accurate fitting and placing of cables, wire conduits, 450 outlet boxes, and the air-conditioning system. The degree of sophistication in the technical system was very little and the project was considered to be technically simple.

The interdependence among different work items was characterised in terms of the nature of the activities and in respect of the degree of physical congestion requiring a great amount of careful programming and co-ordination. The degree of interdependence increased as the project entered the second stage with the commencement of the refurbishment work. There was very little overlap between the two stages of the project, but there was a high degree of technological continuity relating to the interior design of the offices. Despite the simple nature of the building design, it was concluded that the complex intermingling of work flows produced a highly interdependent operation. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, simple and highly interdependent work conditions.

Case Study 3

The number of exceptional cases that required different methods or procedures were few and limited only to some of the variations that could be easily accommodated in the programme. Due to variability of the tasks in general the work unit activities, especially in the operating core, could not have been structured in a routinised way specifying in detail the work steps and the processes.

It is the habit of the contractor to use only barchart as the planning method for site use. The plan was divided up into smaller programmes and each containing the elements of work to be done in two weeks by the subcontractors. These programmes were updated at the end of the two weeks by the planning co-ordinator in consultation with the site agent and the contracts manager. There were in total three major revisions and resequencing of the master plan. Throughout the project there were no indications that the organisation, particularly the operating core, was affected by any degree of uncertainty in performing their functions.

Since the contractor had undertaken a wide variety of industrial projects including different forms of distribution centres under various forms of contractual arrangements, they were well familiar with the construction methods and the design features used in the project. The experience provided a body of knowledge and guidelines reducing the amount of thinking time required to solve work-related problems.

During the design phase a vast amount of time and effort was needed to carry out a thorough site investigation to establish clearly the exact foundation requirements such as the maximum permissible settlement. Due to difficult site conditions, the foundation had to be designed to cater for the settlement and consolidation. A new process was used by the foundation contractor to monitor the installation of piles by instrumentation. This method helped the contractor to find where the concrete did not fully fill the bored hole for the pile by continually monitoring the amount of concrete used, its pressure, and the depth of the pile. The data pinpointed the piles which were suspected.

Although the contributions of the client in the technical matters were not of any help, since he was not fully aware of the range of problems that could be found in foundations or concrete floors, the input of the architect and the design consultants helped to remove any incomprehensibility in the design features.

The project contained five major categories of operation which included the erection of steel frame and the foundation, the construction of the roof, the mechanical and electrical services, the ground floor slab, and the metal racking inside the warehouse. In order to accelerate the work to compensate for the inclusion of variations and minor additions into the programme, the activities among the major operations had to be overlapped. The programme did not have any float time built into it and ultimately became very tight.

There were delays in deciding the type of concrete floor, and consequently that activity had to be inserted into the programme at a late date, thus more engineers had to stay on well into the finishing stages. Also, as agreed in the contract, the client's nominated subcontractor for the racking work started his job eight weeks before the completion date. His operation added to the extent of congestion and near the end of the programme the contractor faced the problem of careful co-ordination to get all the subcontractors to finish their work and move out on time. The presence of subcontractors on site and all at once made the tasks highly interdependent. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, simple and highly interdependent work conditions.

Case Study 4

There was a considerable overlapping of work packages and with construction following close behind the completion of each phase of the design, there was less opportunity for design consultants to consider the design as a whole and to introduce variations without causing delays. Also, with construction activities starting before the completion of all design phases, the process of co-ordinating the basic design work for all the disciplines before awarding any contract was no longer applicable. Consequently, the options of resolving conflicts between the various designers were limited. The change in the scope of work and the rushed delivery of drawings combined with an overlapping of work packages contributed to an increase in the number of drawings that had to be revised. At the outset of the project an efficient review system was not established to clarify the channels of communication and to compensate for the increase in design changes. The number of exceptional cases encountered in the project requiring different methods or procedures was above average causing task variability to the extent which some of the activities were performed with an unstructured and non-routinised way.

One of the striking features was the roof which undulated in response to the internal spatial requirements of the building, and was designed in such a way to allow the roof levels to step up or down unobtrusively. The constantly changing roof level, incorporating many tonnes of structural steelwork and many squared meters of masonry combined to produce an extremely complex-shaped building. Many meetings were held with the architects and engineers to help the subcontractors to overcome many difficulties encountered when coping with the building's complex geometrical form and the high quality of finishes specified.

Occasionally, subcontractors were faced with construction starting on partially completed drawings and specifications, thus a pronounced overlapping of construction activities inevitably increased the problem of co-ordination between the various subcontractors in the field. Managing the interface between the design and construction proved to be the most difficult and crucial aspect of the whole project. In terms of performance, complex shape of the county hall reduced the extent to which the work units could rely on known procedures with specified sequence of steps in performing the tasks, and thus contributing to the complexity of the project.

Most of the major subcontractors had to establish themselves on the site and provide site accommodation and plant in greater measure than might otherwise have been the case, and thus their constant presence on the site was the cause of a great deal of congestion. One of the main objectives of the management function was to improve the performance of the site construction by accurate planning and identification of interrelationships between different trades. As the work on services and finishes neared the peak, the amount of interaction among the workforce increased and introduced new constraints in co-ordinating the site activities. In order to avoid the problems caused by highly interdependent activities, the management contractor moved away from monthly progress meetings with the subcontractors to a weekly and fortnightly rota. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, complex and highly interdependent work conditions.

Case Study 5

The client expressed no particular preference on the method of programming and the main contractor used barcharts since it was considered as the easiest to understand by the site staff. There were major revisions in the design and variations in the requirement which altered the original programme. The work needed to be resequenced 20 times to meet the targets. Usually, the planning is provided as a service by the planning department at the head office, but for minor work packages the site manager took this responsibility. The design responsibilities were with the client's engineers, that is the structural engineer, the services engineer, and the architect who carried out their duties with some uncertainty due to difficulty in knowing the exact conditions of the building in advance, such as the conditions in the ground. The information about many aspects of the structure and location was missing or was inaccurate, which called into question the procedures and approaches used for the survey and inspection of the site. The labour demand was rather unpredictable, though did not cause any disruptions, they had to be imported from other regions of the country which contributed to the cost overruns.

The building was generally simple, but was not designed with particular attention to ease and speed of construction and no concessions to buildability had been incorporated during the preparation phase. These were concerned mainly with interference between trades, concentration of services into particular areas, use of pre-finish components and types of finish which would reduce the congestion of trades towards the end of the project. An example of congestion was that the demolition of central core was going on while piling was being done in the basement. The only unfamiliar aspect of work for the site manager was the use of new insulating material for the basement and the use of special hoist for lifting the materials to upper floors.

There was a great deal of physical congestion and limited access to the building which required operations to be organised considering the close physical configuration of the site. Thus, co-ordination of subcontractors activities and material delivery became a major part of the site manager's job. The main contractor looked at the whole process of construction constituting of several phases whereby the progress of work was dependent on the speedy delivery of approved drawings before commencement of different work packages by subcontractors. However, the site organisation remained the same throughout the contract, and only the number and type of subcontractors changed according to the sequence of activities. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, simple and highly interdependent work conditions.

Case Study 6

Since the project was fairly standard road and bridge work, the programming was routine and the main contractor due to his experience was able to predict and sequence the work activities without any problem. The programming was done by use of barchart and the client did not express any preference for network analysis. There were minor revisions in the design and very little variations in the project scope which did not alter the targets. The design responsibilities were with the client's engineering consultants and were not transferred to different groups, except for the detail design which subcontractors would provide and implement with the comments and approval of the client's engineers. The work was resequenced twice to meet new schedule requirements and that was apart from minor changes in packaged programmes of subcontractors. The labour demand was rather predictable and no disruptions were encountered due to shortage of skilled operatives except for the civil engineering workers who were imported by the relevant subcontractors.

The main contractor was familiar with the applied engineering design and no special or new construction techniques were employed. Since there were no access restrictions, the transportation of construction materials was handled without any difficulty. The co-ordination of subcontractors was part of the project manager's responsibility on the site and he decided to have regular weekly meetings to enhance communication and monitor their work. The amount of off-site prefabrication was very limited and can be considered to be only 10 per cent of the work by volume, mainly relating to the precast beams for bridge structure and the bridge decks.

There was no physical congestion or limited access to the site, and therefore operations were organised considering the open physical configuration of the site. The main contractor identified three major phases in the project. The first was the earthwork which took the first 9 months of the programme and was a measure to see how well the whole work would progress. Second was the structure of bridges and subways which had to start as early as possible and finish on time. The third and last phase was the drainage, sub-base, surface and the road furniture. The framework of the organisation did not change during the progress of each phase and remained the same until near completion. The only difficulty was interfacing the road construction with the bridge work to reduce overlapping. The extent of interdependency was typical of any standard road and bridge work and was considered to be very high. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, simple and highly interdependent work conditions.

Case Study 7

The adequate supply of technical information contained in working drawings, specifications and bills of quantities, and the co-operation of the client's team in approving the detailed designs, contributed to a reduction in uncertainties. Also, the site's requirements for control of information which largely depended on the way the site was organised, including the division of responsibility between the regional office and the site, were satisfactorily met. The contract manager was certain in his mind about most parts of the work and its technological aspects and only the delays in the programme and the resequencing of packages required a certain degree of reliance on predictability of future events.

The main contractor's priority was to conform to the client's specified requirements and in order to achieve this objective the main contractor's engineering department, directly responsible to the regional manager, implemented and continually monitored quality procedures aimed at ensuring that construction operations were carried out correctly at the first time. In order to overcome any task difficulty the department also provided an advisory service to the site in the areas of temporary works design, solution of site technical problems, and liaison with structural engineers and other provisions of technical information. In terms of work methods, the only consideration was the simultaneous construction of the inner and outer walls to their full height so that the work inside could commence as soon as possible, resulting in savings of site times. In the contractor manager's opinion, the project had a rather straightforward nature which made it simple in its technological aspects.

During the accelerated period the project experienced conditions of high interdependency since the increased number of overlapped activities in the live business premises caused physical congestion and difficulties in co-ordination and supervision of subcontractors. In order to cope with the conditions of high interdependency among various task, the site relied upon a combination of discretionary and developmental programmes for structuring work activities. The revised programmes specified the required output to guide unit members in task performance. However, the processes and means to achieve them remained unspecified. The means-end connections for task performance were sufficiently incomplete and inexact to promote adaption through problem solving and learning during the period when a higher pace became a distinct feature of the programme. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, simple and highly interdependent work conditions.

Case Study 8

The contract documents and drawings were fully examined at both the regional office and the site to assess and check the information provided was sufficiently clear in defining the client's requirements and the specified standards such as the site restrictions and provisions, the workmanship, the method of construction and erection, and the records and tests required. The nature of the work required very specialised form of construction to be performed by a comparatively large number of subcontractors. Therefore, an effective liaison with the subcontractors was established which reflected the degree of mutual co-operation for the overall planning and control of the site activities. For example, the main contractor communicated the programmes and provided adequate information to the subcontractors to evaluate the effect of their presence on the site on such things as space and security. The site manager's opinion was that the adequate control of information and the anticipated lack of major revisions or variations made the project predictable in the context of technology.

The objective was to maximise the use of the existing prison estate and build the new complex including the four accommodation blocks within the boundary walls without disturbing the security of the prison. To achieve this objective the construction of the accommodation blocks followed a programme containing two phases. The first phase required the construction of two new blocks for immediate occupation, and the demolition of the two existing blocks. The second phase was planned to follow without any delays in the same sequence. The operational plans which specified the distribution of resources to various disciplines had to meet the objectives outlined by the management plans. However, in complying with the management plans which consisted of the strategy for executing the project the site encountered some difficulties. The considerable demands for communication and feedback between management and site supervision in order to convert the requirements into plans with a reduced operational time were not efficiently met and consequently there were doubts about the exact methods of building the new prison while there were prisoners living in the old blocks constantly needing to use the prison facilities. The complexity of the work was caused by matching the operational plans with the overall management objectives.

The site manager's previous encounters had revealed that interdependency does not by itself cause any difficulty if each activity can be designed to take account of all the other activities with which it interacts, and thus tolerance for interdependence can be developed in case of repetitive works and predictable situations. However, it was widely accepted that in construction operations difficulties arise because programme execution rests on contingencies that cannot be predicted accurately in advance since the pattern of interdependence is dynamic and variant. The elements of variability and contingency puts a greater burden on the co-ordination requirements particularly in the case of specialised processes. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 9

The client's agents overlooked the potential of overlapping the design and construction to achieve an early completion date, and excluded the management contractor from the pre-contract phase and the design function. This lack of early involvement prevented the management contractor from contributing ideas concerning buildability and suitability of the design to facilitate speedy construction. However, this was compensated by the great amount of prescriptive detail that designers incorporated into the documents and the number of drawings that were prepared by the architects and an efficient inspection and approval of the detailed designs provided by the contractors. The influence of technology was described as certain and the variations and changes to the design were made mostly as a result of consultations with the management contractor and the relevant contractors. The process of consultation was utilised in spite of the fact that the PSA dealt directly with its planning and design group in case of any variations.

The site layout and the design principles were well understood and there were no ambiguities concerning the requirements. The structures were of in situ reinforced concrete frames with piles foundations. Some of the buildings such as the sports hall were of load-bearing diaphragm wall construction. The mechanical and electrical services included mechanical ventilation, specialist elements of air conditioning, energy management systems, integrated alarm monitoring systems, high voltage distribution and standby generator supplies. Heating and hot water were supplied by means of dispersed gas-fired boilers and calorifiers. Also, there were some advance works in order to make the site viable for prison development.

These included an access road, the demolition of the existing custody centre, and the adjustments of the site levels.

The move towards a more open prison concept meant that the fire regulations in open space areas had to be observed and incorporated into the design. To comply with the regulations the buildings were subdivided into compartments to inhibit the spread of fire and were equipped with power-assisted smoke extraction and mechanical-ventilation openings. The compartmentalisation within the buildings to restrict the internal spread of fire was a difficult task and it became necessary to engage a fully qualified and independent consultant for advice.

The construction activities were sub-divided into work areas and delegated to site managers in a unified management process. The delegation was necessary because the tasks involved were spread among different sections in geographically separated locations. This arrangement created uncertainty in the minds of the site managers concerning the allocation of resources whenever they had to be commonly shared and utilised. Also, adequate response to technical queries and the transmission of information to the work zones required exact co-ordination among the design team and the various contractors. Although there was very little congestion in terms of the availability of space to work and to deliver and store materials, there was a great deal of interdependency among the work and design processes. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, simple and highly interdependent work conditions.

Case Study 10

During the work on substructure, the project encountered a high level of uncertainty since the ground conditions differed from what they were envisaged and the soils report failed to mention the ground-water which gushed into the excavation as soon as the underpinning operation began. From the start the plans to construct the foundation ran into problems and had to be abandoned or changed. The main problem was the water which came from bowls in the London clay with stemming flows of up to 30 litres per minute. The foundation contractor was called in to inject chemical grout into the subsoil and seal the excavation. However, the chemical grouting operation did not succeed, since the pressure of the grouting had to be limited so that it would not distress the other buildings. Injection at too high a pressure might have swollen the subsoil beneath the adjacent buildings causing them to sway or settle unevenly. The most practical way of dealing with the ingress was to divert the flow into sumps and use 40 small submersible electric pumps to tame and get rid of the flows. Another unpredictable obstacle to the underpinning operation was the underground remains of a previous building and the lumps of concrete that were found everywhere delaying the subcontractor from excavation to underpin the adjacent buildings. The substructure operations needed 4 significant changes in the programme to meet the schedule requirements.

The terms of the party wall agreements, drawn up by the adjacent building owners to set the conditions for construction, included a requirement that allowed no lateral movement of the ground and the existing buildings. The engineers and the subcontractors had a difficult task of devising a support system to prevent the movement of the sides of the excavation and adopted a careful balancing act to ensure that a constant ground pressur was maintained in the subsoil. A too heavy-handed approach would have lead to ground heave with the result that the basement floor area would have bellied upwards causing the side walls to kick inwards and thereby induce movement directly beneath the adjoining buildings. To meet the requirement, complex engineering measures were utilised to support the side walls and the operation was closely monitored by inclinometers which were fitted and read regularly to detect any lateral movement of the underlying strata.

A number of situations was encountered which required work procedures not previously experienced by the main contractor and which were considered to contribute to the degree of task difficulty. For example, the architect specified that the stucco rendering to the external elevation had to be applied with the level of tolerance higher than what was applied to the structure. Also, due to the site congestion a short radius tower crane with the capacity of one tonne was scaffold mounted near the site entrance for the vertical transportation of the materials directly from the vehicles to the floors. The crane stayed in its fixed position throughout the project.

Due to the location of the site in a densely populated business district and the lack of easy access, prior to commencement of the work, arrangements had to be made with the local authority highways engineer regarding the extent of scaffolding and protection to pavements and roads. Permission was obtained to close the pavement completely. However, there had to be no encroachment into the road with hoardings and the traffic had to maintain a smooth flow in the area. The vehicles were not allowed to park or unload during the normal traffic hours and could only operate within a limited period in the early mornings. Restrictions were also imposed on the collection and removal of waste. The removal was only permitted during the weekends and consequently any wastage had to accumulate on the site during the week. The above arrangements and the constraints imposed by the site plan created a high degree of congestion and increased the level of interdependency among the activities. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, complex and highly interdependent work conditions.

Case Study 11

A lift was introduced with standard dimensions and customised finishes. The settlement of the lift interior design was delayed by the architect and the drawings contained several errors which had to be corrected by the manufacturer resulting in additional cost and unpredictable manufacturing programme.

The main contractor was able to provide accurate information and assist the subcontractors to carry out and complete the works in accordance with the details of the master programme and the schedules. The question of how much possession of the whole job was available to any subcontractor at one time was answered and the areas became available sequentially rather than concurrently. The advice of the subcontractors that fast working required wide areas of available work and separate teams working in numerous areas was taken into consideration. Also, to remove the factor of uncertainty further details were provided concerning the period needed for notice to commence the work and the required time for off-site fabrication and delivery. The understanding of the construction manager was that the overall degree of uncertainty was low and only the variations on the refurbishment of the existing structure and the design of foundation led to redesigning details and variability in the work activities.

The overall picture of the ground conditions was essential for the proper design of the foundation. However, the initial site investigation did not provide a clear indication of the nature of the soil and its disposition, and hence the subsequent problems in construction and the uncertainty of the subsoil conditions upset the intial design and the economic assumptions.

Considerable skill and experience was required to apply methods to support the sides of the excavation where the basement ran alongside the adjoining buildings. Prior to any excavation, holes were augered deep below the final level of the new basement and were part-filled with concrete and large steel beams were lowered into position. At the same time, the large and heavily reinforced concrete capping beam that went around the top of the basement's perimeter wall was cast, and the raking steel props that prevented the capping beam from any movement were installed. Adjustable steel trench props bearing on the large steel beams were used to press the steel trench sheet hard against the exposed soil as the excavation around the perimeter and between the large steel beams continued. Only when the heavily reinforced concrete walls and slabs in the basement area were completed did the need for the raking props cease. The design of temporary works to support the excavation and the final construction of the basement wall were the most sensitive areas of the work and added to the complexity of the operations as an inherent part of any refurbishment project.

Inventive methods were used to support the side of the excavation from any lateral movements. They required a great deal of steel-work in the basement including steel columns, large steel beams which were bunched all around the wall line and the raking steel props which criss-crossed the basement, creating a maze of subterranean steelwork, confining the space and causing congestion. Although the main contractor made an attempt to reduce the number of overlapped activities and prevent the possession of the site by many subcontractors at the same time, the level of interdependency among activities especially during the substructure operations and the refurbishment work remained very high. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 12

The design of the arcade containing the retail units was not finalised at an early stage and when the contractor received the client's approval a fast track programme was introduced to complete the work according to plan. The design-build contract provided the opportunity for the early involvement of the contractor's expertise in the planning process and in incorporating buildability into the design. The requirement of the client for early completion emphasised the need for efficient management of information flow and the simplicity of design to help the speed of construction. Also, the familiarity of the contractor with the construction methods for this particular type of building, and the overall policy of providing the site with procedure manuals to guide the operation in a formalised manner, removed many uncertain aspects of the project in terms of design and operation.

The design of the building and the construction activities were understood to be simple. However, situations were encountered which required careful consideration. The senior engineer was given the responsibility for the use and installation of two tower cranes for the purpose of combining their operations for greater efficiency. The cranes were rail-mounted on a suitable sleeper system bedded in concrete to protect the stability of the cranes especially during adverse weather conditions. The cranes were installed to move on two parallel tracks along the two lengths of the site.

In order to prevent methane gas emanating from the landfill site and seeping into the building, it became essential to actively vent the gas according to the imposed regulations by the Inspecturate of Pollution for the design of new-build properties. Forced air ventilation and drainage systems were installed and the floor slab on the ground was sealed against the gas infiltration.

The work activities were highly interdependent and the contractor had to cope with two major challenges of providing the subcontractors with adequate information for tender on defined and independent work packages and the effective co-ordination of construction activities. The drawings were not completed on time for the scheduled tender dates and as a result the tendering of some of the main work packages was compressed towards the end of the design period. This slippage disturbed the original sequence of contract awards, and the impact of compressing and overlapping design activities in order to expedite project delivery led to the acceleration in the work.

The difficulties in putting work packages together and associated construction delays were also assessed to reveal co-ordination problems for overlapped activities. The schedule compression and trade overlaps inflicted a burden on the contractor in terms of available space and restricted time periods in performing the work. One specific problem area was the allocation of relatively short float time in the construction programme of the retail department which was expecting to produce sub-critical delays. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, simple and highly interdependent work conditions.

Case Study 13

The site investigations did not completely reveal the variety of ground conditions and soil properties and it was decided to construct the tunnel by firstly driving a trial crown pilot heading in the westerly direction over the total length of the tunnel. The purpose of the pilot tunnel was to further assess the ground conditions in the variable rock strata, and thereby enabling the consultant engineers to confirm the final design of the full size tunnel. Also, a further design consideration required that the embankment be constructed in stages with allowances for substantial settlement periods which altered the basic concept of the programme and allowed the earthwork settlement to occur while statutory undertakers proceeded with their activities during winter. The variations and programme revisions posed little problem in terms of the predictability of work activities, since the design took account of special provisions in respect of standards, and had also recognised that the construction of each tunnel would be carried out as a major element in the contract and in conjunction with a separate contract for mechanical and electrical services. The overall design concept was therefore developed bearing in mind the need to allow tunnel construction to be phased with earthworks, pavement construction and the many other facets of the work for timely completion.

Planning permissions for the borrow pits and dump sites were obtained during the tender period, but the development of the pits was a difficult process with some onerous restoration conditions imposed by the planning authorities. The extraction operation was similar in each case and was preceded by the excavation of a cut-off ditch within the soil around the perimeter of the pit to trap ground-water and enable the workings to be excavated in dry conditions. Water, which flowed continuously through the overlying gravel bed into the cut-off detches, was collected in sumps and pumped into the nearest available watercourse. This process was maintained throughout the period of operation by the use of backacter-loaded dump trucks and motor scrapers.

Another major concern was the problem of tunnel ventilation during the operation. The cross-sectional area of the completed tunnel was about 50 square metres and calculations of the volume of air required to ventilate the tunnel, using conventional tunnel practice, indicated that very large fans would be required. However, the main contractor doubted that fans could be made to work efficiently and after discussions with the Health and Safety Executive, decided to adopt a different approach. A high-pressure main was provided through the tunnel supplied by a large electric compressor and air movers were fitted at intervals to recirculate the air within the tunnel and to assist the natural airflow through it. All the major plant items used in the tunnel were fitted with catalytic exhaust scrubbers, and the normal supervision levels were increased to try to ensure that all plant drivers switched off their engines during waiting periods. Constant monitoring equipment was used to check on the condition of the air in the tunnel and work was stopped if the limits agreed with the Health and Safety Executive were reached.

The main contractor was unfamiliar with the finishes to wall surfaces which were designed to assist in producing the needed lighting intensity as economically as possible. Within the tunnel, the walls had a secondary lining which was treated with a pale-coloured mineral paint system with a high reflectance value. The surface was smooth and non-absorbent to allow easy cleaning, and on the tunnel approaches, the wall facings were treated with a matt black concrete system to produce as low a reflectance value as possible.

The most obvious contract programme constraint was the essentially sequential construction of the four major stages in the project which included the temporary works, the civil works, the mechanical and electrical services, and the finishes and hand-over. Initial discussions considered whether the work should be organised in two separate contracts, one for the civil engineering work and the other for the mechanical and electrical work, or alternatively in one multi-disciplinary contract. It was decided that a separate contract for such work was suitable to ensure the exercise of detailed control over the activities not directly undertaken by the main contractor. The difficulty with this procedure was that two contractors were responsible for programming the works on site and there were two project managers, each responsible for different parts of what was essentially one project. The decision to proceed with separate contracts was accompanied by the expressed willingness on the part of the two contractors that both teams of resident staff should co-operate and liaise to the full. To facilitate site supervision arrangements, the client's representative agreed to establish a resident staff on the site during the latter part of the project to co-ordinate and conduct regular meetings between the appointed contractors. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 14

Due to the experience of the civil engineering contractor in the field of airport construction and very small introduction of design variations, the overall operation and the work activities were consistently predictable. The apron and the taxiways were constructed of plain slab, unreinforced pavement quality concrete, and the minimum 28-day characteristics of the air entrained PQC formed the basis of the design and provided a flexural strength of 40 MN/M^2 with a maximum permitted failure rate of 1 per cent, and an equivalent cube compressive strength of 35 MN/M^2 from cores cut from the completed pavement. The concrete was laid within road forms utilising a train of self-propelled machines and a 0.75 mm brushed texture depth was provided as both an aid to braking and to enhance the type of grip of tugs when pushing aircraft back from the stands. Joints were formed in the concrete to create 5.25 metre square bays which were sealed with elastomeric sealants resistant to aircraft fuels and oil.

The contractor was well familiar with the typical numerous services for which provisions were made within the pavement works including the water and foul drainage, pits and ductwork, in situ reinforced concrete box gutters, aviation ground lighting and cable installation. The pavements were geometrically designed to accord with the latest international standards and recommendations set out in International Civil Aviation Organisation's documents and complied with the UK Civil Aviation Authority's aerodrome licencing requirements.

The management contractor's engineering department was set up to provide the project with specialist engineering base for the construction team and a technical reference for the client and the design teams as required. Their principal co-ordinating roles and responsibilities covered such aspects as temporary works design and construction, prototype testing materials and analysis, and dimensional accuracy and quality control system. The contributions and responsibilities of the management contractor were of great help in ensuring that the quality standards of the completed work were achieved as specified by the design teams. The civil engineering contractor fully accepted the responsibility of the individual package and was able to assure the quality of the work including that of subcontractors, who were required to produce quality plans describing their control systems, suitably tailored to match the construction method, planned production rates and compliance testing requirements in accordance with the design specifications. The contractor used statistical systems of analysing routine test results and provided quality trends. This procedure became an essential part of on-site pavement quality concrete manufacture where very exacting standards were demanded.

The civil engineering contractor was able to successfully meet the design requirements and the technological aspects of the work were considered as simple, mainly due to familiarity of the contractor with the operations. However, there were also some construction difficulties concerning the use of a needle-punched non-woven geotextile as a horizontal drainage layer to help the consolidation process. The material used to fill the 1000 metre long by 60 metre wide by 3.5 metre deep area for the taxiways was taken from existing clay spoil heaps elsewhere on the development. The difficulty with this procedure was to reduce the pore pressures and speed up the consolidation process so that the subsequent operations such as clay stabilisation and finally pavement construction could proceed as soon as possible. As a result, it was decided to place the geotextile at 1.0 metre intervals to produce the relief of pore pressure and consolidation within the appropriate time.

The need to provide an uninterrupted service to the public during construction was an important planning consideration and the location of the terminal introduced a number of construction constraints which were imposed to maintain a safe yet fully operational airfield. The demarcation boundary between the operational airfield and the construction site was sited so that as much new construction as possible was embraced without compromising the safety of flying operations. The restraint areas were described in the contract documents indicating two periods of possession and requiring two distinct phases of night-shift and day-shift works, resulting in a higher degree of interdependency among the activities. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 15

The degree of details at the planning stage and the amount of information possessed by the organisation encouraged early planning and contributed to the certainty of future activities. The degree of certainty and the accuracy in planning reduced the frequency of updating and major revisions in the sequence of operations, although there were some changes in the planned methods of construction. During any finalisation of work, informal discussions provided more up-to-date information for the preparation of the preliminary programme, including various dates for supply of materials and start of production.

The constraints in the operating conditions and the usual effects of manufacturing inaccuracy and other non-codified factors were well anticipated and understood. The standard of accuracy necessary for ease of assembly and economical welding was obtainable without recourse to elaborate procedures that would increase the shop cost. The dimensional variations within the normal limits of structural fabrication were accommodated in the site assembly with the minimum delay of time in rectification, and the main contractors experience in complex structures suggested how these problems should be tackled.

The overall site operation contained four main categories of work and was divided into four sections, and an operation manager with extensive experience was appointed to supervise and co-ordinate the activities of each section engineer. The repair and strengthening of the towers fell within a category and was carried out over a very difficult river and was governed by unfavourable conditions and winds up to 60 miles per hour.

The operation required few people but was considered as very sensitive and emphasis was placed on accuracy. Other sections were also associated with specific problems. For example, the replacement of welded joints and connections, relating to the suspended deck, stretched for 25 miles and required a high degree of motivation among the welding squads. The third and fourth section engineers were responsible for the management of subcontractors and the logistics requiring the co-ordination of different trades and the provision of support considering the external constraints.

The relatively small area for temporary supports and limitations on permanent works and the fact that the traffic flow had to be maintained throughout the project, severely restricted the options open in designing the temporary equipment and implementing the anticipated construction methods. The priority attached to the completion date in some ways increased the degree of interdependency among various activities. To comply with the programme dates the progress was monitored and assessed regularly, and if for some reason specific items of materials were to be delivered late or had become unobtainable, notification to others was made without delay to make it possible to switch design and detailing effort to sections which could be worked on, or alternatively, where there was complete non-availability, redesign to suit new materials. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 16

Due to the size of the project the construction process has required consideration and assessment of different technologies and alternative combination of labour and equipment in the context of future events and performance. However, the predictions have constantly deviated from the actual outcome, since the initial definition of the building has changed in scope. Also, a few typical factors have added to the uncertainty of the operation such as the delays in obtaining management approvals, errors and omissions in working drawings, late delivery of materials and equipment and many design variations. The existence of outstanding brief changes which are critical to the progress have arisen from the British Library's attempt to optimise space in the first phase and all the relating changes are caused from phasing and staging and the uncertainty over future stages of the project.

The creation of the basements was the main preoccupation of the development and the work involved a range of novel civil engineering techniques on an unprecedented scale to carve out a large basement in London clay without caving in and to prevent the transmission of any ground movement to the surrounding buildings. In addition, the operation had to cope with four London Underground tunnels passing directly beneath the site. The basement construction was of two different types, dictated by the presence of the tube tunnels, and where these cross beneath the site, piles could not be used and instead a reinforced raft foundation was constructed for the two levels of basement up to 13 metres deep. To the south, the deeper basements extending to 25 metres were constructed using the top-down method recommended by the consultant engineer.

Following excavation to remove old foundations, the first contract was for the 30 metre deep secant pile walls around the perimeter of the site to provide a stiff wall and very little ground movement during construction. The management contractor was not familiar with the technique since it is not greatly used in the UK. It involves the formation of piles by 1 metre diameter steel tubes inserted into the holes bored into the ground, and reinforcement is then lowered into the tubes followed by wet concrete. A special oscillating rig is used for inserting the tubes, which allows them to be withdrawn after the concrete piles are cast. The piles were cast alternately such that every other column is cast with a steel beam reinforcement and then while the concrete is still green, the infill columns are cast using a steel cage reinforcement. The final effect is of a linked wall of massive pillars. The proposed top-down method of constructing the basement involved first the construction of the perimeter retaining wall and columns with supporting piles, and next the ground floor concrete slab was laid and the ground was excavated, through the holes left in the floor, below that to the next floor. The effect of each successive floor slab was to brace the secant walls at the perimeter, gradually loading the piles, and thus minimising ground movement. The consultant engineer did not allow the basement floor slabs to be simply cast on the surface of the ground before it was excavated because of fears that ground heave could damage the soffit before the concrete had set. A complicated system was devised in which a tray of falsework was built to a height of 0.6 metres to support the concrete.

The work on superstructure entails other problems. The in situ reinforced concrete frame is faced with an outer skin of brick. However, the architects and engineers are not content to build the brick off conventional concrete ribs or stainless steel brackets. They have devised a complex new fixing system so as to protect the brick envelope from any possible movement by isolating it from the concrete frame. The brickwork cladding is divided into panels 8 metres wide and these are separated from each other and from the reinforced concrete structural frame. To minimise the effects of deflection in the concrete over decades, the panels are mounted on special precast concrete subframes. These are supported by the floor slabs only at the two points of contraflexure between the structural columns, where the deflection is minimal.

The degree of interdependency among activities and the subsequent need for rapid updating and excessive demand for feedback, has encouraged the use of computers in procurement programming, expenditure forecasting and schedule of release dates for information. This has become more necessary due to proliferation of activities and the serious repercussion any delays might have on parcels.

The storage and logistics of transferring the large volume of books from their present locations demand a complex and highly interdependent operation. High density storage specialists have provided the closed aisle storage system to a layout by the architect. A single aisle is used for each block of shelving, and since the shelves are mounted on mobile bases, up to 45 tonnes of shelves can be moved to create an aisle where needed. The sheer volume of books means that an adjustable floor system is to be incorporated to compensate for deflection from the weight of the books, thus allowing the floor to be levelled after loading. The beneficial occupation of the building before completion to progressively fill the bookstacks requires the phasing of the release of the basements. This means that the air conditioning and fire detection and protection systems will have to be installed before the construction of the building is completed. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, complex and highly interdependent work conditions.

Case Study 17

The extensive demands to overlap the trades required extra scheduling efforts to limit the consequences of the fast-track approach which amplifies the impact of any possible disruptions due to the restricted schedules. The delays attributed to the problems of fast-tracking were limited, since a sufficient amount of time was spent on detailing of design packages before awarding the contract that subsequently resulted in far fewer design errors and omissions. Although the speed of construction was of great importance the planned design periods were extended by 20 per cent to provide at least 60 per cent of the design of the main elements before commencement. The lack of information about future events and changes in initial definition of the buildings were considered as common characteristics of any project. However, in this case, the amount of unknown possibilities that affected the construction process and control did not exceed the expected magnitude. Therefore, in terms of variability of work activities and their predictability the project was assessed as certain.

Although a great deal of buildability and efficiency was designed into the first four phases, still due to a number of new and unfamiliar construction processes and activities the overall project was considered as technically complex. In order to do away with the need for expensive temporary shoring and to prevent any ground movements a top-down method of construction was used and the basements were limited to a single level. Apart from the concrete floors poured over metal decks, all wet trades were eliminated from the superstructure including the walls which were all dry lined. Curtain walling was the biggest single item of cost. Elements of the granite and aluminium walls were imported from Germany and Italy and preassembled into panels and lifted into place as finished units complete with glass.

All steelwork was accepted by fire authorities as internal and therefore no site painting was needed. Beams were sprayed for fire protection, but columns were dry cased in plasterboard which provided both fire protection and a base for decoration. Buildings were designed where possible to a vigorous 7.5 metres by 7.6 metres column grid which ensured both that the design was economical in weight of steel and that erection was repetitious and fast. For improved logistics, multi-lifting of several steel beams at once was employed to save crane time and cradles were used instead of scaffold for site connection of steel. Reconstructed metal stairs complete with concrete infill and erected just behind the steelwork were used to minimise the need for ladders and perimeter scaffolding. Finally, in order to meet the requirements for fast-tracking, a new weather protected passenger and materials hoist was specifically developed with a completely uncluttered case interior and the capacity of 20 cubic metres.

The impact of compressing and overlapping design activities in the fast-track programme in order to expedite project delivery was to increase the level of interdependency among and between the work packages. Although the construction work was separated into several self-contained packages and awarded individually to a different trade contractor, a number of parallel critical paths were present throughout the programme. Proper timing in awarding different work packages was critical since a package issued too late or too early might have delayed or interfered with another operation. The award of subsequent work packages after the start of construction was extremely sensitive to the ongoing activities and the availability of the site. The influence of various stimuli on technology was interpreted by the research participant to have produced certain, complex and highly interdependent work conditions.

Case Study 18

Although the overall contract was completed on time, the management contractor struggled against a poor input from the head-office project services. During most phases of the programme there was a lack of drawings, materials, and especially in electrical discipline, incorrect design. In most cases, in order to maintain the programme the design work was remedied at site by the construction personnel, and the materials for remedial work were purchased at site so that work could proceed. The lack of project information made it an onerous job for the materials controller to establish his stores receipt and issue card system. The material issue system was controlled through the planning department using release notes and materials issue forms. This procedure enabled forward planning for estimating materials shortages and allowed time for expediting without affecting the trade contractors programme.

The site performance suffered from the lack of definitive information concerning the project scope with the possible exception of civil and structural works, vague specifications, and inadequate engineering design with particular reference to electrical works. The design team was unable to produce adequate work scope and drawings to meet the requirements for tender enquiries which resulted in additional site work and interruptions.

The installation of vessels in the sterilisation area was a difficult operation, since they had to be manhandled into position and manoeuvred between the existing vessels on the ground floor before lifting onto steel foundations. The installation of new piping within the operating zone provided the bulk of work during the shutdown period, and required innovative and unorthodox design. The use of free space on piperacks was the first priority and some flanges were added at specific locations to increase pre-shutdown piping installation. The installation of piping in a congested piperack was one of the most difficult construction tasks and it often formed a critical path during the shutdown activities. A piperack model was constructed to assist the piping designers and planners to reduce construction man-hours and to be used as a focal point for other disciplines to avoid clashes in piping.

The overriding principle in structural and civil design was to ensure that all construction work can be completed before the shutdown period. This required site verification and the use of co-ordinate system of location for the site. During the civil design, complete verification below ground was not possible and late excavation revealed unpleasant surprises. The result was that the foundations and structures took on odd shapes as a result of compromise. Some of the new foundations were too close to the existing footings which demanded underpinning with extreme caution.

The operating area inside the plant provided a great challenge for the engineers and was viewed as second and third preference for development. The second preferred area was where clear space already existed within the running plant, opening up a pre-shutdown work area for cold activities. The third preference was where space was made available after removeal of existing plant items. almost all the activities in this area were restrained to the shutdown period, and there were reserved for necessities brought about by lack of space or process requirements. Inside the operating area problems arose due to unchartered underground facilities, and exploratory excavations by hand were carried out as an on-going operation, and frequently resulted in measures to clear space by delicately lifting and pulling line cables or diverting oil sewers. The highly interdependent nature of the activities was considered as one of the characteristics of revamp projects specifying progressive completion of installation and hand-over of work packages according to the detailed construction schedules and procurement cycles. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, complex and highly interdependent work conditions.

2.3.1 DIMENSIONS OF TECHNOLOGY - CASE STUDY FINDINGS

The three dimensions of technology were assumed to prevail uniformly across the entire structure of site organisations. In order to determine which aspect of the technical system imposed the greatest influence, case studies were used to review the project situation and provide a point of reference for the contracts managers to make a judgemental decision. The results are presented in Table 2.3.1 as combinations of 1s and 0s, indicating that in the majority of cases the technical aspects of site operations were considered to be certain and complex in nature and highly interdependent. Table 2.3.2 presents the structural characteristics that are hypothesized to emerge as the organisational response to each of the dimensions of technology. The discussions reveal that most organisations experienced predictable tasks and little variability in the operations. This introduces a strong element of certainty concerning the technological aspects of the work and encourages the organisations to move towards a bureaucratic structure with standardised tasks and regulated behaviour. The results also indicate that the performance of the tasks required relatively sophisticated technical systems and the use of unfamiliar design standards and construction methods. In order to deal appropriately with technically complex systems, the organisations tolerated structural differentiation and an elaborate administrative structure including the use of engineering and technical support staff. There was a greater reliance on standing committees and task forces as means of co-ordination. A high degree of interdependence among work activities existed in all the projects and appeared as a dominant aspect of technology and processes in construction works. This implies that organisations select the most adaptable co-ordinating mechanism of mutual adjustment and divert to scheduling information and feedback to standardise the outputs. The influence of various stimuli on technology was interpreted by the research participant to have produced uncertain, complex and highly interdependent work conditions.

Case Study Results, Table 2.3.1

Case Studies

Dimensions of Technology

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Certain	1	0	1	0	0	1	1	1	1	0	1	1	1	1	1	0	1	0	12
Uncertain	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	6
Simple	0	1	1	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	7
Complex	1	0	0	1	0	0	0	1	0	1	1	0	1	1	1	1	1	1	11
High Inter-dependency	Highly Interdependent																		18

1 indicates total compliance with the corresponding dimension
0 indicates non-compliance with the corresponding dimension

Dimensions of Technology, Table 2.3.2

Dimensions of Technology		Prime Structural Characteristics
Certain (67%)	:	Work in the operating core is broken down into routine and standardised tasks which can be executed by unskilled workers; standardisation drives the structure towards a bureaucratic structure since the control is more formalised and impersonal.
Uncertain (33%)	:	The middle-level of the organisation closest to the operating core is less structured and encounters less repetitive tasks; the work in the operating core has less procedural specifications and is too fluid to be formalised.
Complex (61%)	:	A greater use of engineers and technical support staff promoting horizontal decentralisation and greater use of liaison devices at middle levels; more reliance on task forces and standing committees as substitutes for more rigid methods of coordination.
Simple (39%)	:	At middle levels the reliance on liaison devices is very little; there is less participation by the technostructure in making technical decisions; the administrative ratio is very small.
High Inter-dependency (100%)	:	An increase in the capacity to handle communication by devicing informal methods and avoiding the lines of command; facing complicated situations the organisation selects the most adaptable coordinating mechanism of mutual adjustment; the organisation can also divert to scheduling information and feedback to standardise the outputs.

Chapter Three

3.1 DESIGN PARAMETERS

The basic components of organisational structuring fall into four broad groups of design parameters, and are considered as formal and semi-formal means of grouping and co-ordinating the organisational activities to establish distinct patterns of behaviour and thereby affect how an organisation functions. These groups of parameters are: design of positions, design of superstructure, design of lateral linkages, and design of decision-making system.

3.2 DESIGN OF POSITIONS

The two parameters influencing the design of individual positions are the specialisation of job and formalisation of behaviour.

3.2.1 Job Specialisation

Jobs are specialised in two dimensions of horizontal and vertical. Horizontal specialisation is concerned with the differentiation of activities within each function and refers to the specificity and narrowing down of tasks assigned to any particular role. It determines how many different tasks are contained in each position and how broad or narrow each task is. It has been suggested that an increase in horizontal specialisation increases productivity for repetition in work helps its standardisation, there is saving in time lost in switching tasks, and there is improved dexterity from specialising in one task. Vertical specialisation separates the actual performance of an activity from administration of it in the belief that a different prospective is required to determine how the work activities should be performed and what should be the method of control.

The participation of most of the main contractors in a narrow category of work made it possible to predict the labour demands and skill requirements for various tasks. However, the production work force was divided into a variety of trades and the main contractors relied extensively on the practice of subcontracting for the supply of materials, plant and labour for at least three-quarters of the works. The services provided by the subcontractors were diverse in nature and included specialist suppliers of frames, cladding, mechanical and electrical services, various equipment, components and finishes and most of whom contributed both to the detail design and construction of their portion of the work. In management contracting, the members of organisations were given particular tasks, mainly in the area of administration and their involvement was to some extent vertically enlarged, especially among the line managers, to provide a degree of autonomy over the supervisory decisions.

Due to multiplicity of inputs and the diversity of conditions from one site to another, a large number of ad hoc decisions had to be taken by the managers on site often without reference to senior staffs at the head office. In addition, to avoid all the problems of a bureaucratic structure, such as sharp divisions of labour and extensive unit differentiation, the site management had to rely on a combination of different bodies of knowledge to achieve co-ordination rather than to rely on standardised skills. They were expected to respond to particular problems necessitating quick action and use a flexible process in making decisions. This description was mostly valid for small to medium size projects where structural differentiation was minimum and the scope of responsibilities for line managers were wider. In large projects, including those where the task structuring was done by dividing the construction activities into several geographical sections, each headed by a section manager, multiple differentiation was a common factor in organisations. The multiple differentiation, especially in the operating core, broke the job further into smaller components and minimised internal transportation and handling time and ultimately obtained greater horizontal specialisation. Horizontal specialisation narrowed the perspective of the workers, making it more difficult to relate to the activities in other sections. Therefore, the control of the work was passed on to the section managers and general foremen to co-ordinate by direct supervision, and the responsibility for integrating the activities of subcontractors was with the project managers and project co-ordinators. The complex pattern of differentiation required special efforts for integrating the tasks and vertically specialising the roles of individuals in the organisational hierarchy.

3.2.2 Formalisation

Formalisation of behaviour is the design parameter by which the work processes of the organisation are standardised to reduce its variability, to achieve co-ordination, and to control the organisation by developing work methods and instituting written rules and procedures for all situations. Formalisation is used when tasks require precise, carefully predetermined co-ordination and when the organisation operates under conditions of certainty. Another aspect of formalisation entails the specification of requirements for holding a position. In particular, an organisation can specify the training and experience needed as a prerequisite for assignments of positions and establish recruiting and selection procedures to screen the applicants. Depending on the work in question, the organisation can either control it directly through its own procedures and rules, or it can achieve indirect control by hiring appropriately trained professionals. The relationship between formalisation and training can either be supplementary or complementary. Also, the presence of trained employees or professionals appears to cause a decrease in needs for formalised rules and procedures, since professionals have internalised standards to guide them in the conduct of their work.

In order to increase the capacity of the site organisation to co-ordinate a complex and highly interdependent pattern of activities, it was recognised that the need for continuous communication among repetitive activities had to be reduced. To bring about a greater tolerance for interdependence the contractors introduced limited formalisation and standard operating procedures by distributing various company procedures and circular manuals for reference and implementation. These manuals covered four areas of site operation including site engineering, planning and information control, subcontract management, and health and safety procedures and defined the responsibilities of site staff. For example, in the case of excavation and temporary works, the senior engineer was responsible for all planking and strutting of excavations and the selection of the temporary works. He would prepare the drawings and work out all the calculations for the design of support systems and obtain approvals for the scheme from the client's representative. Where temporary shoring was not covered fully by the manufacturer's data or other specialists information, the site engineer would have obtained approval for the design from a suitably qualified engineer. The need for checks was agreed by the project manager and the site agent in conjunction with the resident contract manager, and the excavation register was kept up to date by the foreman in charge of the operation and included any actions necessary to keep the excavation in safe order following the weekly inspections. In order to prevent faults and avoid major defects, most organisations relied on a more controlled and disciplined method of ensuring quality. A formal method of auditable checks was devised and every item of work in a project was put on a quality check-list together with the mandatory specifications. As soon as a subcontractor or a tradesman finished an item, it was signed as complete and dated and then checked by the section engineer for final approval. Although the written policy manuals and performance guides were available, the common practice to regulate behaviour was mainly by indoctrination and experience of staff and frequent site and head-office meetings to reinforce the formalisation factor by reviewing and familiarising the employees about the expected behaviour and performance on site.

Those main contractors who had their own labour force conducted in-house training with the supervision of the Company's Craft Apprentice Master and in conjunction with the appropriate technical colleges and training boards. The employees were regularly interviewed by senior managers to provide encouragements for progressive career development and individual participation in in-house or external training courses. The management contractors had a high annual intake of graduate trainees specialising in building subjects including graduates with general degrees interested in a management career. The complex nature of management contracting which management functions cannot easily be formalised by rigid guidelines, required the organisations to rely on professionals who had expertise in well-defined fields to provide the support services to site management. The training courses were designed specifically to comply with the individual requirements in their future positions, but experience was considered as the main prerequisite for job assignments especially when there was a need to reallocate people from one project to another.

3.3 DESIGN OF SUPERSTRUCTURE

General and specific tasks when positioned according to the degree of specialisation and formalisation, are then combined and grouped into units considering the size, in terms of the number of personnel at each level of organisation, to form the overall hierarchy and to determine the organisational boundaries. The superstructure is represented by two design parameters of unit grouping and unit size.

Unit grouping is a fundamental means to co-ordinate work, since grouping establishes a system of common supervision and creates a common measure of performance and requires positions and units to share common resources. It is through this process that the system of formal authority is established and the hierarchy of organisation is built incorporating the co-ordinating mechanism of direct supervision into the structure. The concept of unit size attempts to decide how many positions should be grouped into one unit under a single manager. The variations in unit size is explained in terms of the mechanisms used to co-ordinate work, and although these control and co-ordinating mechanisms are to some extent substitutable, it can be expected that the replacement of one method by another would significantly affects the size of a unit. For example it can be reasoned that the more co-ordination is achieved through the systems of standardisation, designed by the technostructure, the less time the manager needs to spend on the direct supervision of each employee, and thus greater numbers of employees can report to him. In order to reveal the effect of size on structure among different site organisations, the number of employees reporting to their immediate supervisors, specifically the first-line supervisors and the number of management levels to indicate whether the structure is tall or flat, are looked at.

The complexity of the building process and the importance of obtaining repeat contracts made increasing demands on the management ability of main contractors to achieve the required levels of performance. Due to the importance attached to each contract, regional directors usually took charge of the projects and appointed the contract managers to be responsible for selecting the site staff, running the contracts, and heading the site organisations which were mostly based on previous arrangements of similar projects. The site organisations reflected three ways that positions were grouped into work units. The support staff were grouped according to the specialised skills that members brought to the organisation. The operating core and line managers were grouped on the basis of their specific tasks and services rendered to the organisation, and units were formed according to geographical regions which in this case were the construction areas within the building sites. Also, occasionally the grouping of some positions were based on the specific requirements and wishes of clients to see an inclusion of certain services, such as safety, in the site organisations rather than providing them from the head-office. Emphasis was put on direct supervision and mutual adjustment within each work unit to overcome the problems of co-ordination. The work units were mainly constituted by subcontractors and because of divisionalising the site activities, especially among the larger projects, the project managers and co-ordinators played an important role in programming the activities for better integration.

The site organisations were characterised by a clear division of tasks that corresponded to the disciplinary specialisation of supervisory and engineering personnel leading to a functional structure. The functional structure was more appropriate for operations where the project plan called for distinct functional phases, since such arrangements reduced the requirement for interdisciplinary co-ordination. For certain projects a very rigid work division was not recommended since it would have caused problems for works involving numerous interfaces between multiple disciplines. This condition could have resulted in extensive co-ordination requirement to integrate the diverse activities and created conflict and inconsistency in dealing with external interfaces due to unclear goals across various subunits. Therefore, in many building projects a departure from a rigid functional structure was detected. This departure introduced matrix management where the responsibilities for direction and co-ordination within an area of the project were split between the area manager and his subordinates. The area manager acted as a project manager for a specific portion of the work and his major responsibilities included the development of area plan, co-ordination of craft disciplines within the area, reporting and problem identification, and cost and schedule monitoring. This arrangement provided early problem identification through more specific control and enabled the work to be divided into more manageable subunits while still maintaining the advantages of centralised support staff grouping. Functional structure with area management and craft staff was favoured by a number of main contractors for relatively large building projects in which by maintaining a strong technical consistency over the entire project, the breakdown of work activities into discrete areas became feasible.

The issue of size has been treated in the literature as an imperative that dictates certain structural configurations. However, there was very little indication to suggest that in structuring the site organisations the relationship between size and structure had received any focused attention. There were no specific criteria employed to determine the size and the hierarchic levels. Project objectives, work methods, and the scope of the contracts together defined the project situation and the project situation in turn dictated the size most suitable for performing the required tasks. The only aspect of size that was realised was that any increase in size especially during the peak of operations would strain the management span of control of line managers and could result in an increase in hierarchical levels followed by vertical decentralisation to reduce the supervisory loads. In order to assure the most effective utilisation of available management, support and craft resources the contract managers were prepared to sustain a manageable span of control by imposing limits. The size of operations in terms of personnel varied according to the required combination of interconnected processes categorised by different types of trades and the degree of supervision through levels of control up to the contract manager. Although there were variations in terms of size throughout the life of projects, which brought about an extensive increase or decrease in the number of operatives according to the rate of progress and the new demands, the structure of site organisations encountered very little change.

The hierarchic levels among the site organisations varied from a flat structure with 3 levels to a tall structure with 9 levels each producing a clear chain of authority with relatively small groups at each supervisory level and relatively small work groups in the operating core. They employed between 5 and 49 site staff which varied during the projects according to the workload and the change of emphasis on the type of trades. An elaborate administrative hierarchy was seen as the cause of interruptions of the vertical flow of information, and hence an attitude was taken up towards the ability of subordinates that allowed spontaneous co-operation without the constant intervention of the supervisors. Standardisation of skills and work processes by trade specialists reduced the need for intraunit coordination which allowed for an increase in unit size with moderating effects on the administrative hierarchy. This moderating effect widened the span of control and produced relatively flat structures in the operating core. This was seen as the cause of encouragement for mutual adjustment and informal communication as a coordinating device.

The long chain of authority in tall structures reduced the time the contract managers needed to spend on direct supervision and provided more time for non-supervisory aspects of their jobs such as collecting information and developing liaison contacts between the site and the head-office. At peak of the operations there were between 8 and 100 subcontractors employing between 30 and 250 operatives and on average handling more than seventy-five per cent of the work by contract value. The involvement of subcontractors put a notable emphasis on boundary control and consequently the contractors were required to maintain a limit on the number of people allowed on site for the reasons of safety and congestion of work place. High level of interdependency among tasks produced a greater need for contact between the line managers and the operatives so that the activities could be closely monitored and supervised. However, when the interdependent tasks became complex, they became more difficult to supervise directly and instead there was an increase in face-to-face communication among the operatives. In order to encourage this informal interaction the work units remained small enough to promote frequent contacts outside the chain of authority.

3.4 DESIGN OF LATERAL LINKAGES

Planning and control systems that standardise the outputs and liaison devices that are incorporated into the formal structure constitute the third group of design parameters.

3.4.1 Planning and control systems

Planning and control are two parts of one series of activities, since plans standardise specific characteristics for a desired output and control system monitors the results of the implementation at the same time as it provides data for further planning. Two fundamentally different kinds of planning and control systems are commonly used to regulate outputs in organisations. One is performance control which is concerned primarily with the measurement and after-the-fact monitoring of the results of a whole series of actions, and the other is action planning which is oriented to specifying and determining in advance the specific decisions or actions required by the organisations. However, as suggested in the literature, the two planning and control systems are not considered as being independent, since there are a number of links and crossovers between them. The overall performance control objectives lead to the development of specific programmes which are used to generate operating specifications and plans. The impact of proposed actions on overall results are assessed by feedbacks of information from performance control to action planning, and hence the linkages between the two systems.

A formal system of project planning was commonly used to specify a blueprint for activities and comprised of a master plan for identifying and representing each element of the work linked to a time scale in a proper sequence. The master plan provided the overall strategy and established various kinds of general standards from which the detailed development of major activities were produced into a set of programmes. These programmes communicated the project intentions to all members of the team and provided tactical guidance to various trade specialists. The selection of programming techniques was based on the responsibilities of particular recipients. The network analysis technique was employed by the planners to compile the logics; that is, to specify the activities and to identify the links, the programme was translated into bar-chart for site use, and S curves were used by top line managers to assess the overall progress. In order to monitor the progress, observations were made and supplemented by reports to see where the project was in relation to the programme. If any deviations from the stated objectives were detected or if there were any design changes, the plan was then revised and updated to produce the new optimum solution corresponding to the changed requirements. This was considered as the natural cyclic process of review and revision with little impact on the organisational structure.

The discussions with contracts managers revealed that when there is little interdependency between work activities or between the work of subcontractors, regulating performance was considered as a more convenient means of co-ordination and various trades were given more freedom to determine their own specific actions. However, when the internal structures of organisations were broken down into a series of functional units distinct organisational goals could not easily be identified, and hence action planning emerged as an option to co-ordinate the activities as an integrated system. Although to standardise work processes and outputs direct supervision was a key co-ordinating mechanism in the operating core, it could not contain all the interdependencies, and thus skilled craftsmen were given discretion in their work with the possibility of mutual adjustment to regulate their activities. Action planning was considered as the last resort to be utilized mostly by the subcontractors in case any deviations from the intended objectives were encountered.

The cost was monitored by comparing the total cost to date with valuations gross of retention, and in some instances the unit costs were compared with those in the tender. Usually, in case of any deviations, the main contractors avoided influencing the work of subcontractors by action planning and instead tried to resolve the problems by informal systems such as discussions and meetings so that the members of various trades could exercise their own judgment and expertise in taking corrective actions. In projects involving design-construct the cost control began as soon as any design work was commenced and for this reason a detailed preliminary cost plan formed part of the presentation. As design work progressed the preliminary cost plan was used as a cost monitoring and control document and was updated as necessary during the design development phase. After the scheme was approved the final cost plan was the only document available for cost management during the construction phase. Once work commenced financial statements of anticipated final cost were prepared and submitted to the client on a monthly basis. Cost comparison exercises also continued through the later sections of the work and were reported monthly along with any variations on work carried out on site. Clearly defined procedures were adopted to ensure the expenditure was adequately controlled such as the appointment of a single representative for issuing instructions to the contractors, and a procedure established whereby all the client's requests for changes and architect's instructions were issued as drafts to quantity surveyors and contractors for comments on costs and programme implications.

In management contracting cases, the clients retained the traditional responsibilities for final approval of designs, placing of contracts and approval to commit expenditure. The client's agents held a full range of responsibilities for the preparation of all the drawings and specifications, cost planning and control, contract documentation, tender letting and authorisation, and valuation and preparation of final accounts. The management contractors worked closely with the design teams both in the design offices and on the sites to identify from the designs and studies of site constraints the necessary individual construction and common site services packages. Individual procurement and construction programmes were prepared to cover all stages of work from commencement to commissioning and handover to clients. These formed the management framework for the project control and were the basis of the agendas for the formal site meetings. Each of the subcontracts stipulated weekly progress and monthly control meetings with the management contractors and reports were presented to all participants including the members of the design team. Monthly cost reports were compiled from pre-contract cost checks, subcontract tenders reconciliations and post-contract reports quoting committed expenditure along with estimates of variations and anticipated construction costs. These monthly reports were widely used by all the parties to monitor the overall financial performance.

3.4.2 Liaison devices

When direct supervision is not sufficient to achieve co-ordination and where the organisation cannot standardise its work processes, a whole set of liaison devices are developed to promote contacts and informal communication between individuals and work groups. Liaison devices are flexible mechanisms that encourage informal relationships and are superimposed on the structure to reduce its inflexibility and upset its formalised pattern of behaviour.

The use of a liaison position, that is, to superimpose a person without any formal authority onto the formal structure to by-pass the vertical channels and increase the amount of contact between the site staff, was never practiced. The project managers were responsible for joining direct links between the line staff groups and were considered as the communication centres of the organisations. However, considerable degree of informal communication among managers, engineers, and planners commonly existed, especially unscheduled interaction appeared to be appropriate to the work carried out at the middle levels of the structure.

Due to involvement of a number of trade specialists and the complexity of their tasks, the work units were greatly differentiated and horizontally specialised. Therefore, the site activities required integration and collaboration among specialised interdependent tasks leading to mutual adjustment for interpersonal co-ordination. There was no need to use stronger liaison devices and formation of permanent standing committees since frequent meetings between the site staff and the subcontractors and monthly meetings with the participation of the architect and other consultants were held to discuss and resolve problems. However, there was an extensive use of task-forces where people from different parts of organisations were frequently brought together to form committees to study specific problems in parallel to their main responsibilities. As construction proceeded the speed of work became a greater influence on decisions, because of a shift in the relative importance of cost and time. Consequently, a change in speed and accuracy in providing information on the progress of construction became necessary. The scope and frequency of meetings between different parties increased to achieve more rapid response to actual and anticipated problems.

3.5 DESIGN-MAKING SYSTEM AND PROCESSES

There are a number of ways of examining decisions, however, contemporary theories stress the amount of participation as the most common measure in determining the patterns of decision-making. In the language of decision-making the word process also holds an important place, since by revealing the theoretical arguments in the process of decision-making, it may become possible to identify certain characteristics of the structure and to understand the locus of decision-making and style of activities between groups and individuals. Decision-making system and processes are the last group of design parameters and are discussed in the following paragraphs.

3.5.1 Decision-making system

Organisations constantly try to balance the opportunities for central planning and disposal of resources against the advantages of delegation and the restrictions imposed as a consequence of planning. The success of creating such a balance depends on the ability of organisations to match the need for co-ordination with demands for participation, and to resolve the conflict between centralisation and autonomy. The concept of centralisation and autonomy are looked at by considering the comparative element. To find a point of reference the contract managers were encouraged to derive their answers from their personal experiences and previous conditions in former organisations.

The contract managers were responsible for the total control over the operations, the execution of the contracts, and the supervision of men, and since diversity of conditions and particular project characteristics meant that many decisions had to be taken often without reference to the head office, occasionally they became resident on site. In setting up the organisations, the aims of the contract managers were not to establish relationships between structural variables but to find the most effective organisation for efficiency and control. Therefore, they avoided pursuing the theoretical concept of decentralisation and instead concentrated their attention on the practical distribution of decision-making authority amongst the line managers. The discussions revealed that formal authority usually rested in the line structure and there was little transfer of power to the non-managers and support specialists. However, some structures experienced horizontal decentralisation when informal power was delegated to the support specialists to the extent that they contained expertise to make technical decisions. Although, the line managers with formal authority and support staff with technical knowledge joined together in regular site meetings to discuss issues, the distinction between them remained clear.

A general conclusion was reached that the suggestion that decentralisation is a means of distributing authority, influence and power is at odds with the general indicators that it is about maintaining control over the organisation. The limited increase in formalisation allowed the organisation to delegate the right to make decisions without losing the overall control as those delegated were made within guidelines designated by the rules. Thus, decentralisation did not necessarily carry with it any delegation of discretion or weakening of the authority of the managers and the supervisors in the hierarchy. However, having power to make decisions gave one neither the information nor the cognitive capacity to make them, but as observed by the contract managers, because of the degree of complexity in the construction operations decentralisation was a very widespread organisational phenomenon.

Particularly, due to high degree of interdependency among the activities of trade specialists, there was not an intentional shift of power down the chain of authority but a natural delegation allowing those with job responsibilities to perform their tasks more efficiently. Therefore, decentralisation of the operating core became a permanent feature of the decision-making system, though line managers remained responsible for supervision of respective subcontractors and the co-ordinative decisions. The structure of organisations also contained some evidence of selective decentralisation, since the organisation tended to delegate power for operational decisions farther down the chain of authority than power for legal, financial and procurement decisions.

3.5.2 Decision-making processes

From two groups of theories, rational and behavioural theories of decision-making, five models were selected with the attempt to include all possible aspects of a decision process relevant to structuring organisations. These models are the adaptation, the behavioural choice, the organised anarchy, the political and the contingency model. In order to describe the decision process and investigate which model complies most to decision situations, from each a number of propositions were extracted. The degree of conformity of the propositions were tested by referring to the experience of the managers who were positioned at the top of the organisations hierarchy, such as area directors, contract managers, and project managers. During the course of site visits and interviews it became apparent that other members of project organisations who were positioned at the lower levels in the hierarchy would not have the necessary information or the experience to give appropriate responses to the questions. Therefore for the purpose of data collection the top management was the target of analysis and it was required to keep this level constant throughout the research.

The strength and evidence of any fit between the proposed models and the decision process was measured by asking the respondents to state the degree of conformance of these propositions when applied to the task of structuring site organisations and how confident they are in the accuracy of their responses. The assigned degree of conformance and the level of confidence were chosen from the scales ranging from 0% to 100% and were multiplied together to produce the total measure of conformity. The total measures of conformity for all models, in the sample of eighteen projects, were then compared and conclusions were drawn to reveal and establish a decision process most frequently referred to in organisational structuring. These models and their propositions provided a conceptual framework for data collection and analysis regarding which theories best describe the decision-making processes. However, the propositions did not attempt to include all the possible aspects of the theories, but rather focused on implications relevant to organisational structuring.

The following pages provide the list of propositions extracted from the five decision-making models and Table 3.1 presents the average degree of conformance for each proposition for the sample of eighteen cases. To identify the existence of one dominant model or the aggregate of several processes from different models, the propositions are ranked and arranged as a histogram, in Figure 3.1, according to the extent of their conformance to the prevailing processes as perceived or observed by the management of corresponding organisations.

3.5.2.1 Adaptation Model

Proposition 1: Organisational learning and experience.
The process of learning, in the context of adaptive behaviour, relies on the ability of the organisation to draw inferences and modify behaviour on the basis of experience. The learning ability is an inherent characteristic of any organisation and is proportional to the understanding of events and ability to recall history.

Proposition 2: Organisational learning and incentives.
Organisations provide incentives for their employees to learn from feedback of previous experience. Incentive in learning is associated with motivation, some measure of factors that influence an inclination to process information and modify behaviour.

Proposition 3: Experience dominates structuring.
The organisations are not structured from scratch by taking into consideration the new project situations, but are rather repeated depending on the success of the organisation in achieving the objectives of previous projects.

Proposition 4: Ambiguity dominates decisions.
Any change in organisation is resulted from adaptation despite unclear relationships between the organisational structure used and the results obtained in terms of the success of the project.

3.5.2.2 Behaviour Choice Model

Proposition 5: Managers encounter limited rationality.
Managers try to comply with the rational analysis, but changes in project goals and project situations, informational and computational limitations, and personal preferences prevent them being rational in their decision process.

Proposition 6: Unfavourable performance stimulates search.
Managers usually search for organisational alternatives when they are faced with reduced levels of performance. The search for alternatives can involve additional costs to the contractor or the client, and can mean changes in any of the design parameters.

Proposition 7: Structures include intentional ambiguity.
Uncertainty about the outcome of future actions and human limitations in dealing with them are seen as intrinsic in the decision-making situation. Therefore, in order to deal with limitations, managers intentionally leave portions of the organisation undefined or ambiguous.

Proposition 8: Managers satisfice in structuring.
Managers understand that their time and resources are limited and therefore are forced to implement structures which result in only satisfactory levels of performance. They cannot afford to search for excellence in goal attainment.

3.5.2.3 Organised Anarchy Model

Proposition 9: Unclear technology.

Although the organisation manages to survive and even produce, its own processes are not understood by its members, since it operates on the trial-and-error procedures. These processes are mainly related to the construction methods that the organisation has to employ to do the work.

Proposition 10: Participation is often fluid.

Participants vary in the amount of time and effort they devote to different domains of organisation and their involvement and responsibilities vary from time to time. Therefore, the decision-makers change, during a project or from one project to another, for any particular kind of decision.

Proposition 11: Random decision style.

The organisation contains a basket of ready-made solutions which in case of a decision situation, when a problem becomes activated, is searched to find an attractive choice for the problem.

Proposition 12: Entry time determines outcome.

In the theory of organised anarchy decisions are influenced by the entry time; that is the time a problem becomes visible. Thus, entry time determines the sequence of solutions and the priority of problems have little effect on this sequence.

Proposition 13: Solutions generate problems.

Managers adopt organisational structures when the situation does not require their use. Similarly, managers make decisions on non-existing problems. This misunderstanding of the project situation and inappropriateness in decision-making generates new problems.

3.5.2.4 Political Model

Proposition 14: Power determines structure.

All members of organisation seek power to control others and to control the decisions that affect their own work. Therefore, the structure of organisation is determined by individuals who ignore some of the organisational goals and try to acquire power by control of information and by management of critical resources.

Proposition 15: Decisions are made by negotiations.

The structuring process is influenced by negotiations among top-level managers and self-serving coalitions among horizontally and vertically differentiated units, mainly due to the existence of ambiguities surrounding goals and inconsistent orderings of preferences.

Proposition 16: Individual capability modifies structure.

The professional's power derives from the fact that his work is too complex to be supervised or to be standardised. This would give the member considerable autonomy in his work and would increase decentralisation and make him irreplaceable in the view of organisation.

3.5.2.5 Contingency Model

<u>Proposition 17:</u> Rational process determines structure.

In making decisions, managers go through a series of steps leading to a rational process and encompassing the following activities: define objectives, define project situation, develop alternative courses of action, forecast outcomes, evaluate alternatives, and finally select and authorise an alternative.

<u>Proposition 18:</u> Situational change causes structural change.

A key element in the contingency model is the management ability to respond to varying situations and produce change to bring about an alternative structural form most appropriate under a new set of conditions. The varying situations are applied to everything inside the organisation and may consist of changes in leadership, the number of employees, the knowledge base it must draw upon, and the change in organisational effectiveness.

<u>Proposition 19:</u> Environment determines structure.

There is a continuing interaction between organisation and its environment which comprises virtually everything outside the organisation such as the type of clients and competitors, its geographical setting, the economic and political situation, and the climate. The response to these factors can be classified as either competitive or co-operative, however few organisations approach either extreme, with profound effects on structure.

Proposition 20: Technology determines structure.

Technology is considered as a defining characteristic of organisations and is primarily a phenomenon which greatly influences the design of operating core. Since, in construction, the outputs are non-standard, the operating core could likewise not be standardised or formalised and therefore its structure is organic. The co-ordination is done by mutual adjustment and direct supervision rather than by formalising behaviour. The first-line managers, being directly responsible for production, work closely with operatives in small work groups. Due to the nature of co-ordination, there is little need for an elaborate managerial hierarchy above the operating core or a large technical support staff beside them.

Table 3.1
Models of Decision Making Processes
Adaptation Model

	Case Studies																		
Propositions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average Degree of Conformity
P1	.5 x .9	.5 x .9	.6 x 1	.75 x .75	.9 x 1	.2 x .9	.7 x 1	.7 x .8	.4 x .75	.9 x .9	1 x 1	.6 x 1	.9 x .8	.25 x 1	.5 x .9	.75 x 1	.8 x .9	.3 x 1	10.3025/18 = 0.572
P2	.4 x 1	.6 x .9	.35 x 1	.5 x .7	.4 x .9	.3 x .9	.2 x .9	.4 x .9	.5 x .8	.6 x .8	.2 x 1	.5 x 1	.2 x 1	.3 x .9	.5 x .9	.4 x .9	.4 x 1	.3 x.9	7.28/18 = 0.404
P3	.6 x 1	.9 x 1	.2 x .9	.6 x .6	.6 x .9	.9 x 1	.9 x 1	.4 x .9	.45 x .8	.2 x 1	.4 x 1	.75 x 1	.5 x .9	.7 x .9	.7 x 1	.9 x 1	1 x 1	.5 x .9	10/18 = 0.555
P4	.6 x .9	.75 x .8	.5 x .9	.75 x 1	.4 x .9	.65 x 1	.8 x .9	.6 x .9	.4 x 1	.8 x .8	.5 x .9	.6 x .9	.4 x 1	.4 x .8	.9 x .9	.65 x .9	.7 x 1	.6 x 1	10.095/18 = 0.561

Table 3.1 (cont)
Models of Decision Making Processes
Behaviour Choice Model

	Case Studies																		
Propositions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average Degree of Conformity
P5	.8 x .8	.9 x .9	.8 x 1	.6 x .9	.7 x .8	.4 x 1	.7 x .7	.6 x 1	.5 x 1	.5 x .8	.6 x .8	.75 x .9	.5 x .8	.7 x .9	.65 x .8	.8 x 1	.7 x 1	.8 x 1	10.445/18 = 0.580
P6	.9 x 1	.5 x .75	.8 x .9	.7 x .7	.3 x .9	.2 x 1	.8 x .9	.3 x 1	.7 x .7	.5 x .9	.4 x 1	.3 x .9	.8 x .8	.2 x 1	.6 x .8	.3 x .9	.45 x .9	.25 x .9	7.645/18 = 0.425
P7	.3 x .85	.35 x .9	.75 x .75	.7 x .9	.2 x .85	.4 x .8	.8 x 1	.4 x .9	.25 x .9	.4 x .9	.3 x 1	.3 x 1	.3 x .9	.2 x .85	.25 x .95	.4 x 1	.3 x 1	.2 x 1	6.17/18 = 0.343
P8	.6 x .9	.9 x 1	.6 x 1	.9 x .9	.7 x .9	.7 x .8	.3 x .7	.55 x .9	.6 x .8	.7 x .9	.5 x 1	.4 x .9	.4 x .7	.6 x .8	.4 x .9	.5 x .9	.2 x 1	.9 x 1	9.245/18 = 0.514

Table 3.1 (cont)
Models of Decision Making Processes
Organisational Anarchy Model

	Case Studies																		
Propositions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average Degree of Conformity
P9	.25 x .9	.15 x 1	.2 x .95	.3 x .6	.15 x 1	.15 x .9	.4 x .7	.35 x .8	.3 x .9	.2 x .9	.15 x 1	.2 x 1	.2 x .9	.3 x 1	.15 x 1	.3 x 1	.1 x 1	.25 x 1	3.670/18 = 0.203
P10	.3 x .85	.15 x 1	.2 x .7	.3 x .9	.3 x 1	.05 x .9	.7 x .6	.3 x 1	.3 x .9	.3 x .8	.15 x 1	.15 x 1	.2 x .9	.2 x 1	.1 x 1	.3 x 1	.25 x 1	.2 x 1	3.892/18 = 0.216
P11	.1 x 1	.05 x 1	.05 x 1	.1 x .9	.15 x .9	.05 x 1	.1 x .9	.4 x 1	.1 x .9	.2 x .9	.1 x 1	.1 x 1	.1 x .9	.1 x .9	.2 x .8	.1 x 1	.2 x .9	.1 x .9	2.055/18 = 0.114
P12	.7 x .9	.5 x .9	.45 x .9	.2 x .8	.4 x .9	.1 x .85	.2 x 1	.3 x .8	.3 x .7	.5 x .8	.7 x .9	.15 x 1	.35 x .9	.4 x .8	.15 x 1	.2 x .9	.2 x 1	.3 x .8	5.225/18 = 0.290
P13	.1 x .9	.2 x 1	.3 x 1	.1 x .9	.4 x .9	.35 x .9	.3 x .7	.2 x .9	.1 x .8	.1 x 1	.3 x 1	.1 x 1	.05 x .9	.3 x 1	.2 x .9	.5 x .8	.1 x 1	.1 x .8	3.520/18 = 0.195

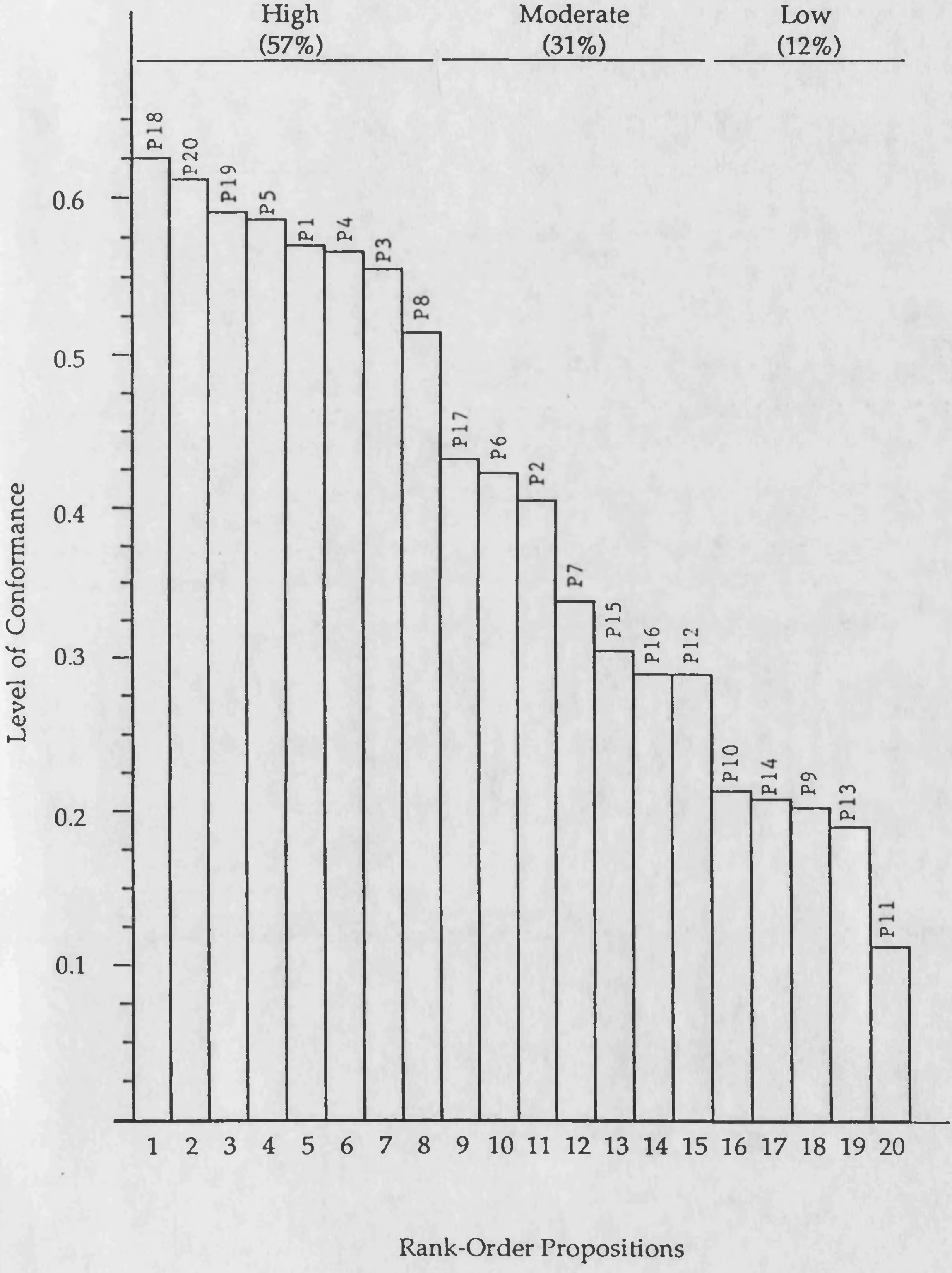
Table 3.1 (cont)
Models of Decision Making Processes
Political Model

	Case Studies																			
Propositions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average Degree of Conformity	
P14	.1 x 1	.1 x 1	.2 x 1	.1 x .9	.35 x 1	.2 x .9	.6 x .8	.25 x 1	.1 x .9	.1 x .8	.15 x .8	.3 x .9	.45 x .8	.4 x .9	.1 x .9	.15 x 1	.25 x .9	.25 x 1	3.745/18 =	0.208
P15	.25 x 1	.1 x 1	.5 x 7	.3 x .7	.2 x 1	.1 x .95	.7 x .9	.45 x .9	.5 x .9	.2 x .9	.15 x 1	.3 x 1	.3 x .8	.2 x 1	.3 x .9	.8 x .9	.3 x 1	.4 x 1	5.450/18 =	0.303
P16	.4 x .9	.6 x .9	.8 x .9	.8 x .8	.7 x .9	.35 x .85	.2 x .8	.2 x 1	.4 x 1	.05 x 1	.1 x 1	.3 x .9	.25 x .9	.1 x 1	.05 x .9	.3 x 1	.1 x 1	.1 x .9	5.227/18 =	0.290

Table 3.1 (cont)
Models of Decision Making Processes
Contingency Model

	Case Studies																		
Propositions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average Degree of Conformity
P17	.5 x 1	.2 x .9	.5 x .9	.3 x .8	.4 x .9	.4 x 1	.3 x .8	.65 x .9	.2 x .8	.7 x .9	.6 x 1	.4 x 1	.5 x .9	.6 x .9	.7 x 1	.5 x 1	.35 x 1	.5 x .9	7.734/18 = 0.429
P18	.8 x .9	.75 x 1	1 x 1	.6 x .85	.3 x .8	.85 x 1	.6 x .85	.4 x 1	.8 x .8	.5 x .9	.8 x 1	.7 x 1	.7 x .85	.7 x .9	.6 x .9	.7 x 1	.4 x 1	.8 x 1	11.235/18 = 0.624
P19	.55 x .9	.75 x 1	.6 x .85	.7 x .75	.65 x .9	.5 x 1	.7 x .9	.45 x 1	.3 x .9	.8 x .8	.75 x 1	.8 x .9	.65 x .9	.5 x .9	.6 x .8	.8 x .9	.7 x .9	.9 x 1	10.590/18 = 0.588
P20	.65 x 1	.6 x 1	.75 x .9	.8 x .9	.4 x .8	.65 x .9	.6 x .9	.65 x 1	.6 x 1	.6 x .9	.6 x 1	.8 x 1	.6 x 1	.6 x .9	.8 x 1	.75 x 1	.45 x 1	.8 x .9	11.00/18 = 0.611

Rank-Order Histogram, Figure 3.1



Chapter Four

4.1 SUMMARY OF FINDINGS AND CONCLUSION

The central themes that have guided the development of this thesis are primarily drawn from the contingency theory, advocating the appropriateness of alternative structural forms under a specific set of conditions, and behavioural and rational theories to represent the multiple perspectives of decision-making processes. It seems useful first to briefly outline the major theoretical assumptions and biases that are embedded within such theories to reveal some of the difficulties associated with the ability of the models to provide accurate description of organisational reality and interpretations of empirical findings.

One of the most contemporary issues in organisational research focuses on structural contingency; that is, environment and technology are related to the structure of complex organisations (Thompson, 1967). Dill's (1958) earlier case study was probably one of the first attempts to trace variations in organisational structure to environmental factors. Thompson (1967) saw the emergence of a new perspective in which organisations were viewed as open systems subject to environmental and technological conditions, a perspective departing from the traditional practice of endorsing or prescribing an ideal or universal type of organisation (Likert, 1967; McGregor, 1962). Drawn primarily from large-scale empirical studies, the theory relies on a few assumptions that have been explicitly stated to guide the contingency research. The first explicit assumption is that there is no one best way to organise; the second is that any way of organising is not equally effective under all conditions (Galbraith, 1973). The theory then asserts that in order to be most effective, organisational structures should be appropriate to the work performed and to the environmental conditions facing the organisation. To construct a well-developed set of interrelated hypotheses, this research relied on the contingency theory to suggest ways in which the empirical relationships expected when a contingency process is believed to be operating ought to be explained. However, a number of contingency theorists and researchers (Mohr, 1971; Pennings, 1975) have discussed the assumptions that are hidden in the language of the theory and the problems that appear to account for some of its mixed empirical support. Some of the assumptions are also reflected and problems shared in whole or in part in this work. These range from asymmetrical language in theoretical statements to more subtle issues, such as the embedding of uniform properties in theoretical assertions.

Organisations commonly experience multiple environments and technologies across their entire range. The disparities encourage organisations to respond with a differentiated structure and to set up work constellations which are selectively decentralised and are allowed to develop structures most appropriate to their subenvironments. For example, one constellation of an organisation may be organically designed to handle dynamic conditions, while others, operating in stable environments, may be structured bureaucratically (Mintzberg, 1979). However, it is often convenient and reasonable approximation to treat the environment and technology as uniform along each of their dimensions, either because some of their more placid aspects do not really matter to the organisation or because one aspect is so dominant that it affects the entire organisation. The conditions of uniformity were assumed in the discussions of case studies, because the demands of subenvironments for a differentiated structure was found to be negligible and that the assumption helped to produce consistent use of design parameters in analysing the structures.

The literature on contingency theory contains a good deal of conceptual confusion. Many of the studies are not comparable because the measurement instruments vary and it is often not clear what is meant by environment and which of its variables have more explanatory power for structural differences among organisations. Furthermore, it seems that some authors equate dimensions of environment with the dimensions of technology and have a tendency to combine the variables descriptive of both. This lack of clarity is substantially due to the over generalised character of theoretical statements. Statements from contingency theorists and researchers suggest that a particular structure should be appropriate for a given environment (Thompson, 1967), that organisations are more successful when their structures conform to their technologies (Woodward, 1965), that an organisation's internal states and processes should be consistent with external demands (Lawrence and Lorsch, 1969), that organisations should attempt to maximise congruence between technology and their structure and adapt their structures to fit their technology (Perrow, 1970), that technology and structure need to be properly aligned (Khandwalla, 1974), that a coalignment should exist between environment and structure (Lawrence, 1975), and that communication and flow of information should match the nature of the task (Tushman, 1978). In order to provide a greater precision and to differentiate environment from technology this research relied on the definition of environment as the aggregate of surrounding conditions and influences that mainly consist of persons, groups, and organisations with which the focal organisation has exchange relations. March (1988) argued that in simple models of organisational change, it is usually and conveniently assumed that action is taken in response to the environment but that environment is not affected by organisational action. However, he asserted that organisations can also create their own environments. For example, organisations are frequently combined into an ecology of competition in which the actions of one competitor become the environment of another, and therefore each competitor partly determines its own environment. Also, organisations create their own environments by the way they interpret and act in a confusing world. It is not that the world is incompletely or inaccurately perceived (Slovic, Fischhaff, and Lichtenstein, 1977; Nisbet and Ross, 1980), but that actions taken as a result of beliefs or perceptions of individuals construct an environment which can be highly inconsistent with reality. Moreover, it is possible for organisations to act strategically in environments they help to create, since they are not ordinarily experienced in a way different from other environments. To discuss the three dimensions of environment and determine which ends of the three continua are most applicable and exert more influence to shape the organisations, it was therefore necessary to devise a number of measures that included some of the intermediate variables that are thought to affect the organisational actions and consequently help to create an environment.

In this research the term technology referred to the internal operations of the organisation and the means that are used to convert inputs into outputs. Although organisations often try to buffer their operating core they cannot completely seal off themselves from external constraints, and therefore to operationalise the effects of technology on structure the outputs were seen as contingent upon the internal operations as well as those factors beyond the control of organisations. The consistency among definitions was maintained throughout the research by the development of precise hypotheses concerning the dimensions of environment and technology and by identification of their measures and associated intermediate variables. Assumptions related to the contingency theory and the extracted hypotheses, together with the measures of the dimensions of environment and technology are summarised and presented in Tables 4.1, 4.2 and 4.3.

Theoretical Assumptions, Table 4.1

	Contingency Model
Assumptions	* Organisation's environment and technology are considered as two separate and distinguishable concepts. * Various environmental and technological conditions require different responses in the design of structure. * Asymmetrical nature of relationships between the structural variables (design parameters) and the environmental and technological conditions. * Environment and technology are treated as uniform along each of their dimensions and are assumed to have uniform impacts on the organisation.

Measures of Dimensions of Environment and Technology, Table 4.2

		Contingency Model
Dimensions of Environment	Stable-Dynamic	Unpredictable shifts in the economy, variations and changes in client's requirements, changes in overall project objectives, shortages of skilled operatives.
	Simple-Complex	Degree of difficulty encountered in coordinating the work of subcontractors, involvement of client and his representatives, difficulty in programming or controlling the work.
	Friendly-Hostile	Adverse relations between involved parties, project locations, competitive environment, extreme weather conditions.
Dimensions of Technology	Certain-Uncertain	Reflected in the intermediate variables of predictability of work activities and variability of work items.
	Simple-Complex	Reflected in the intermediate variables of comprehensibility of the work, the use of unfamiliar design standards or construction methods, and the number of simultaneous work activities.
	Low Interdependency-High Interdependency	Degree of physical congestion, mechanisation, and the distinguishable successional number of phases in the construction process.

List of Hypotheses, Table 4.3

	Contingency Model
Hypotheses (Environment)	E1: The more dynamic the environment, the more organic the structure. E2: The more complex the environment, the more decentralised the structure. E3: The hostile environment drives the organisation to centralise its structure temporarily.
Hypotheses (Technology)	T1: The more regulating the technical system, the more bureaucratic the structure. T2: The more complex the technical system, the more decentralised the structure. T3: The more interdependent the range of activities, the more decentralised the structure and greater functional specialisation.

The basic components of design parameters in the context of project situation were discussed in the previous chapter. It is evident that these parameters when related to technical and environmental framework can take various forms and their interrelationships can empirically demonstrate the existence of a link between the technology, environment and organisational structuring.

The main characteristics of organisations were found to be the co-ordination of specialised and differentiated tasks, often most clearly visible at the executionary level. The participation of a variety of trades in the production of the work and extensive reliance on the practice of subcontracting for the supply of materials, plant and labour required a combination of different bodies of knowledge to achieve co-ordination rather than to rely solely on the standardisation of skills and routinisation of processes. To control the work and to link and integrate the diverse tasks, direct supervision by line managers appeared to be the most common and acknowledged method of co-ordination. Due to a relatively small number of specialists employed at the building sites, it was required from the line supervisors to be technically competent. Their technical competence was, in most cases, of the kind acquired by long practical experience rather than by professional training. High level of interdependency among tasks produced a greater need for direct contact between the line supervisors and the operatives so that the activities could be closely monitored. As a result, the labour force was broken down into small primary working groups with small spans of control creating a more intimate and informal relationship between the group and their immediate superiors. For more complex tasks with a high degree of process interaction or for unstructured and unspecified subtasks, mutual adjustment mainly in the operating core and frequent contacts outside the chain of authority were commonly relied upon for work-flow co-ordination. Although direct supervision provided by a small managerial hierarchy was considered as the primary means by which the non-routine and routine activities were structured as an integral system, organisations could not sufficiently cope with all the work-flow interdependencies and therefore allowed personal liaisons across unit boundaries and discretion in the work of skilled craftsmen to achieve the desired standardisation of outputs.

Regular assessment of project performance was considered as a more suitable means of control and evaluation of project delivery. In some cases where the internal structures of organisations were broken down into a series of functional units, distinct organisational goals could not easily be identified and hence action planning emerged as an option to regulate outputs and specify the activities for a tighter control. However, the extensive use of action planning and imposition of specific decisions were often avoided since they were thought to impede the flexibility of organisations to respond creatively to the environmental uncertainties. The site organisations of civil engineering projects were characterised by a clear division of tasks that corresponded to the disciplinary specialisation of supervisory and engineering personnel leading to a functional structure. The functional structure was more appropriate for operations where the project plan called for distinct functional phases, since such arrangements reduced the requirement for interdisciplinary co-ordination. The organisations of large building projects adopted a more flexible matrix structure that enabled the integration of numerous interfaces between multiple tasks while retaining a good deal of decision-making at the centre. The smaller organisations were characterised by centralisation of power for formulation of strategy and minimal formalisation to allow rapid response. The structure had to ensure that strategic responses reflected full knowledge of the operating core and thus it was necessary for the line supervisors to be familiar with both the technical aspects of the projects and the operating systems.

To reduce the need for continuous communication among repetitive activities and to bring about a greater tolerance for interdependence, limited amount of formalisation and standard operating procedures were introduced in circular manuals covering four main areas of site operation, planning and information control, subcontract management, and health and safety procedures. Indoctrination, training and work experience of staff appeared as primary means of standardisation and in conjunction, written policy manuals and performance guides were considered as reinforcing factors in familiarising the employees about the expected behaviour and performance on site. The organisations did not reflect an arbitrary desire for great order, and the nature of the tasks and their variability made precise and carefully predetermined co-ordination inappropriate. A need for a variety of co-ordination mechanisms to create an equal balance across the entire structure of organisations was clearly evident. The formal and informal methods were often intertwined and sometimes indistinguishable conveying the important message that formal structures reflected official recognition of naturally occuring behaviour patterns. However, the behavioural specifications of jobs and standardisation of procedures or extreme formalisation of behaviour through written rules were not favoured as either sufficient or as primary forms of standardising the work processes. Instead, mutual adjustment and less formal methods of communication such as regular site meetings emerged as significant factors in helping the organisations to cope with the variability of activities and their required standardisation. The overall effect of a stable environment where organisations can relatively predict their future conditions, and a regulating technical system where the operations are routine and predictable impose similar demands and as presented in hypotheses E1 and T1 produce a bureaucratic structure with more formalised and impersonal means of control. However, the above findings do not support the hypotheses E1 and T1 and rejects their underlying assumptions concerning the relationship between structure and the two environmental and technological dimensions of stability and certainty.

The contract managers were given total responsibility over the control of operations, the execution of the contracts and the supervision of the project team, and since diversity of conditions and particular site characteristics meant that many decisions had to be taken immediately without reference to the head office, they often took resident on sites. In setting up the organisations, the aim of the contract managers was not to establish relationships between structural variables but to find the most effective arrangement for efficiency and control. Organisations were temporary project-based units which drew their project teams from either the functional department at the head office or from specialised contractors. The discussions revealed that formal authority usually rested in the line structure and there was little transfer of power to the non-managers and support specialists. However, some structures experienced horizontal decentralisation when informal power was delegated to the support specialists to the extent that they contained expertise to make technical decisions. Although, the line managers with formal authority and support staff with technical knowledge joined together in regular meetings, the distinction between them remained clear. Due to the complexity of construction operations and the interdependency of activities, especially among trade specialists, vertical decentralisation was considered as a very widespread organisational phenomenon and a natural delegation of power allowing those with job responsibilities to perform their tasks more efficiently. Therefore, vertical decentralisation of the operating core became a permanent feature of the decision-making system, though line managers remained responsible for supervision of respective subcontractors and the co-ordinative decisions. In accordance with the hypotheses E2 and T2, the results are indicative of the fact that participation in decision-making retained a positive association with the environmental and technological complexity. The distinction between the two dimensions are made clear by their definitions, but the hypotheses are suggestive of similar structural impacts amounting to horizontal but mostly vertical decentralisation. The influence of the technical system was not solely restricted to the design of structures in the operating core since as exhibited in the organisational charts, a more elaborate support structure consisting of staff specialists was a common feature of many organisations with complex jobs.

The organisations were found to be open systems dependent on exchanges with their environments and often in a problematic way dominated by constraints and influenced by unfavourable condition. The hypothesis E3 was based on the theoretical premise that observed hostility in environment decreases the dependence of organisations on decisions reached through joint processes. The research found no evidence to support the assertion that organisations respond to turbulent and threatening environments by redefining the authority for action and restructuring into a more centralised form as long as the hostile conditions persist. The effects of external conflicts and disputes encouraged the contract managers to redraw the organisational boundaries and act as buffer agents to protect the balance of responsibility and authority of each of the individual members of project teams from unnecessary interventions and outside pressures.

The above findings are summarised in Table 4.4, which indicate substantial variations and lack of complete conformity between the theoretically extracted hypothese and the actual structural characteristics of the organisations which were operating under the specified environmental and technological conditions.

Summary of Findings, Table 4.4

	Rejected	Accepted	Structural Characteristics
Hypotheses	E1		Stable conditions of environment do not produce a bureaucratic structure and highly formalised behaviour. Instead there is a reliance on more flexible coordination mechanisms and less rigid work procedures.
		E2	Decentralisation of authority mainly along the vertical dimension.
	E3		Hostile conditions do not cause a centralised system. However, organisations have a tendency to redraw their boundaries and create buffer agents to protect the organisation from external influences.
	T1		Certainty in technical systems do not break down the tasks into routine and standardised work processes resulting in a more bureaucratic system.
		T2	Greater flow of informal communication and use of liaison devices, and decentralisation along the horizontal dimension.
		T3	Avoiding the formal lines of commands and adapting a flexible coordination mechanism.

The basic ideas behind the hypotheses locate the cause of structure mainly outside the organisation by relating environment and technology, as two separate concepts, to structural variations in accordance with functional imperatives for fit or accommodation in an asymmetrical relationship. However, since some authors (Blumer, 1966; Silverman, 1970; Jehensen, 1973) have treated the central features of organisational life as the interaction of individuals and the decision processes through which particular structural patterns are generated, it was decided to incorporate these efforts among the design parameters in order to highlight the existence of any link between the decision-making processes and the structural characteristics.

The decision processes as an important factor in organisational structuring were identified in terms of their dominant conceptual frameworks and their underlying assumptions. The emphasis was placed on the need to examine how decisions arise, are perceived and are formulated both descriptively and prescriptively as a critical task of upper-level management. To start the investigation it was first necessary to outline the major theoretical concepts in order to lay a foundation for later discussions of alternative approaches and proven alogorithms of formulated processes. The theoretical concepts were treated within five commonly accepted and referred models of organisational decision processes, representing a range of realistic but conflicting ideas with different assumptions and biases. The purpose of presenting them in the form of propositions, to test their conformity against the actual processes, was to identify the relevant issues in organisational structuring rather than to offer an exhaustive review of literature. The results obtained from the research interviews and the average degree of conformity for each proposition was rank-ordered and presented in Table 3.1 and Figure

3.1. Although the five decision-making models utilise differing assumptions and introduce specific biases into the task of structuring, the results indicate that all five models with various degrees are embedded in the norms of organisational decision-making, and depending on organisational cultures and environmental conditions, any of the propositions could be evoked at any time to constitute part of the multiple representation of a process.

The results of the research interviews surfaced a particularly strong support for both the adaptation and the contingency models with emphasis on natural selection perspective which views the fit between organisational environment and structure as the outcome of an adaptation process influenced by strategic choice that ensures only the survival of best performing organisations and produces a state of equilibrium in configuration of structures after a long and gradual process of change. This view suggests that there is little focus on understanding how contextual factors affect structural characteristics and how these interact to explain the variations in performance.

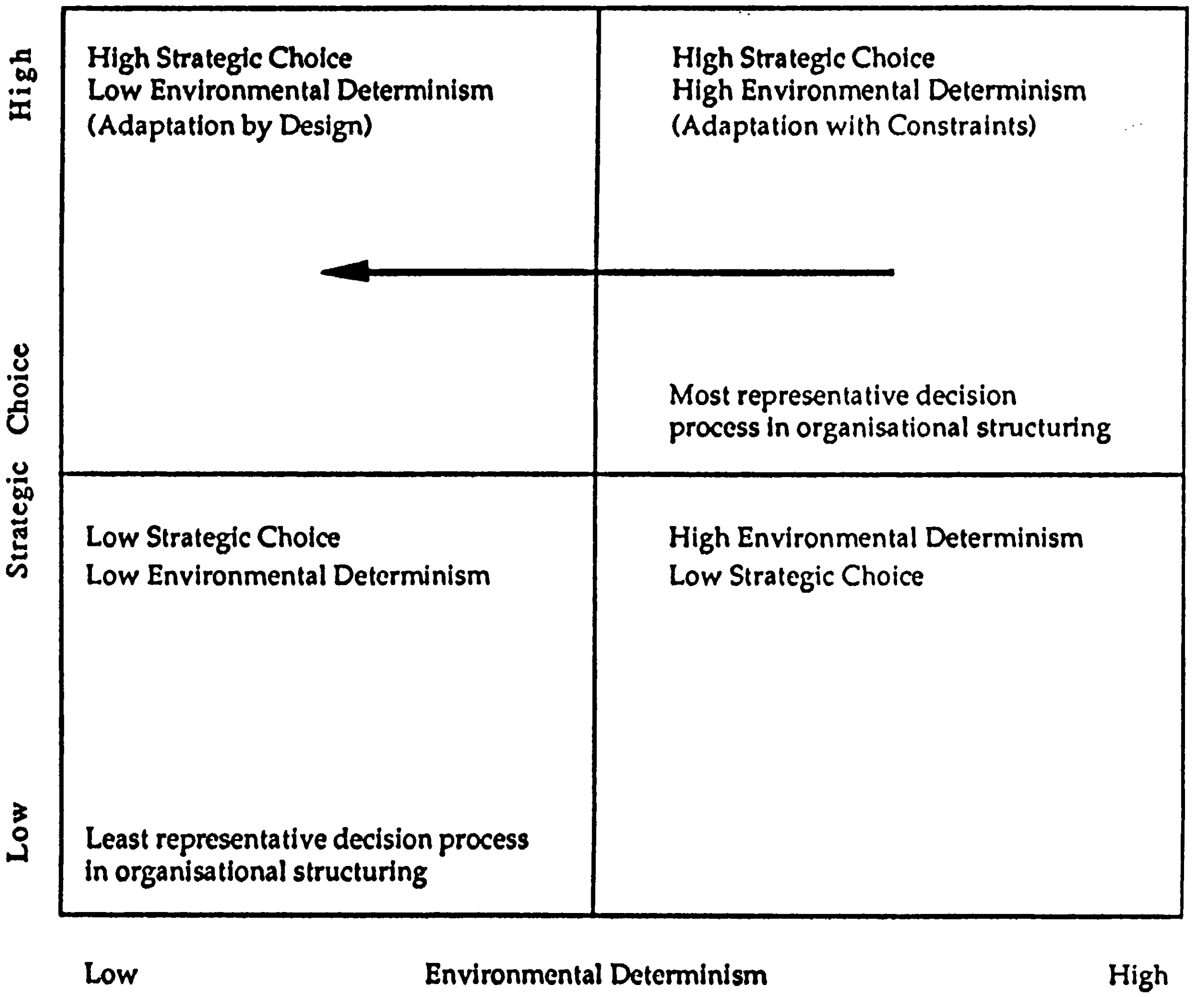
The prevailing assumption in recent literature is that strategic choice and environmental determinism represent mutually exclusive and competing explanations of organisational adaptation. The central argument treats adaptation as a process reflecting choice and selection versus one in which it is a necessary reaction to peremptory environmental forces. Astley and Van de Ven's (1983) review suggests a major difference in current theory between a deterministic and a voluntaristic orientation in theories of organisational adaptation. One of the dimensions in their typology is a continuum ranging from determinism to voluntarism, which is divided to place major schools of decision analysis into two mutually exclusive categories. Although their placement of schools of analysis in one category or the other is intended solely to classify them, it clearly implies the competing nature of the debate on the question of whether the decision process of structuring is managerially or environmentally derived. The results of this investigation are also indicative of the fact that decisions in organisational structuring conform to the dominant processes of adaptation described independently by the contingency model, emphasising strategic choice, and the adaptation model reflecting environmental determinism. However, there is a difference since the research inquiry reveals the interactive nature of relationship between the two models and the interdependence of processes with individual interpretations. This view is supported by Weick (1979), who argued that construction of mutually exclusive categories and focusing on origins and terminations of variables such as choice are problematic and distorting for theorists and practitioners alike. The critical issue is the ability to investigate the process of structuring as a reciprocal relationship between two sets of models and how choice is both a cause and a consequence of environmental influences.

The support for the propositions relating to the models of adaptation and contingency are represented by the average degrees of conformance and thus can be identified as the processes most frequently referred to in organisational structuring, but the assigned degrees for each individual project vary considerably from low to high. This denotes variance on levels of assertiveness and defines the domain of power in the relationship between environmental determinism and strategic choice and the relative vulnerability of each in an interactive setting. The organisations experiencing the conditions of high environmental determinism and low strategic choice enjoined very little control over exogenous factors which created a relatively unstable context for decision-making and provided few viable strategic options. Although external conflicts and constraints limited managerial action, the organisations facing a host of problematic dependencies actively sought ways to lessen the control or influence of environmental forces by allowing high degree of solution driven search directed towards the solution of specific problems.

At the opposite extreme some organisations existed under the more munificent and favourable conditions of high organisational choice and low environmental determinism. Due to lack of problematic dependencies on scarce resources and few political constraints, the organisations purposely defined their domain and influenced the exogenous conditions under which they operated. The autonomy and control made innovations and proactive behaviour more attainable and helped to bring about appropriate managerial actions to mitigate against peremptory environmental demands. The research interviews revealed one additional set of conditions that although are relatively neglected by the literature emerged as the most representative decision processes in organisational structuring. Most projects experienced high strategic choice and high environmental determinism that together formed the turbulent context for adaptation process. Under these conditions certain immutable environmental factors severely constrained behaviour and affected decision-making, but the organisations nonetheless enjoyed simultaneously high choice with control over some ends but primarily over means and internal processes. This is partly attributed to the inherent characteristic of the industry structure which allows some control over intraorganisational processes but very little over extraorganisational influences and outcomes, providing top level managers with a primary task of manoeuvering around externally imposed prescriptions and mitigating against environmental demands and dependencies. The analysis of case studies concerning the internal and exogenous forces revealed that although both organisations and environmental elements experienced power, each side was vulnerable in some areas but simultaneously was able to create dependencies in others. Throughout the life of the projects constant attempts were made to remove the vulnerabilities and extend the control over construction operations by strategic actions. This required the absorption of the interplay of various political and economic forces and building entry barriers to diffuse hostilities and reduce problematic dependencies on contractors or clients. However, the common objective was to remain under the conditions of high strategic choice and high environmental determinism, gain additional influence over the environment and move towards the relatively advantageous conditions of high strategic choice and low environmental determinism.

As depicted in Figure 4.1, the most apparent conclusion is that the interdependence and interactions between strategic choice and environmental determinism define the dynamic process of adaptation, which is the function of relative strength and type of dependency between organisation and environment, and which construct the decision-making model in structuring project organisations. An implication of this result is that the simple models relying on the conceptual construction of mutually exclusive and competing explanations of cause and effect are not sufficient to capture the complexity of the decision process.

Dynamic Process of Adaptation, Figure 4.1



The propositions drawn from the behaviour choice model were examined and the empirical evidence also provided a strong support for the propositions 5 and 8, suggesting that actual decisions are made under conditions of bounded rationality and that managers implement structures which result in only satisfactory levels of performance. The major premise of the model as indicated by March and Simon (1958) is that decision-making is the fundamental process of behaviour and performance within organisations and decisions are made under a number of external and psychological constraints. The model presents a behavioural view which challenges the assumptions of classical decision theory and reveals the inherent weaknesses in models of rational choice as being appropriate as guides to intelligent actions but problematic for predicting behaviour and anticipating future preferences. Compatible with the findings of Cyert and March (1963) the research shows management awareness of limitations on attention and concern for the costs of obtaining information as an explicit part of the structure of decisions. The concept of bounded rationality implies that only a few alternatives can be considered simultaneously, but the research indicates that decisions are determined more by choices among alternatives than by decisions with respect to search. Although it can be suggested that the level of aspiration was the main cause of dynamism in organisations and assured periodical search, decision-making and search for structural designs were found to be not spontaneous and continuous activities and little support was directed towards search as a response to patterns of success or failure in performance. Due to the conditions caused by bounded rationality, organisations rarely maximised goal attainment in their decisions and tended to evaluate decision alternatives against standards that set minimally acceptable levels of attainment on objectives and client's requirements to meet satisfactory levels of expectations rather than look for alternatives with highest possible expected value. The existence of human constraints was widely recognised to influence and limit the process of search and the selection of alternatives. Rather than considering all the possible options from the most preferred to the least preferred, and following a more comprehensive process of search until the emergence of an optimum solution, an incremental process was pursued to maximise the probability of achieving the target goals with the satisficing effect of the final outcome.

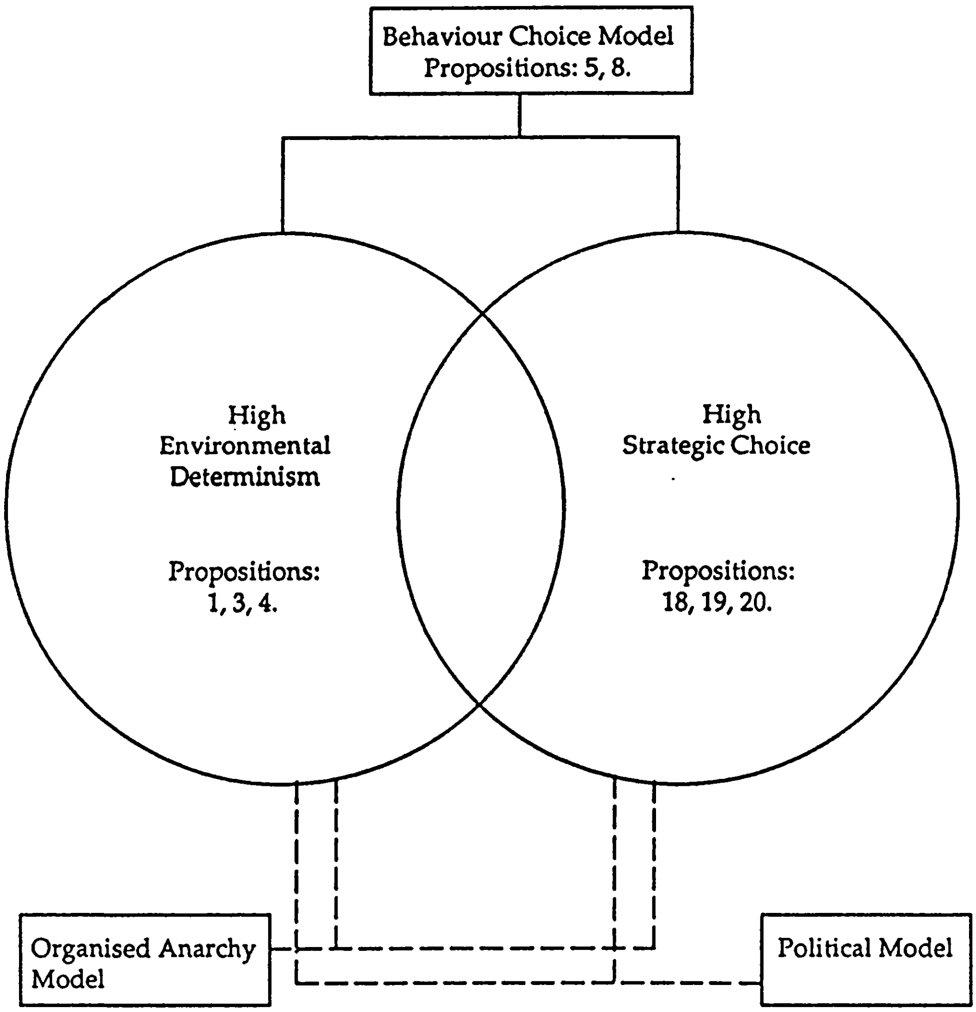
Literature has argued the existence of a variety of bases of power in organisations, ranging from distinctly individual in nature to sources of power which are identified as organisational. Constraints imposed by organisations through such factors as performance evaluation systems and reward procedures influence the decision-makers by suggesting that certain choices are preferable in terms of their payoff. The implication of these organisational constraints, when coupled with human limitations, formulates a political model as a decision process concerned with the consequences of actions and expansion of influence to protect self-interest. Credibility of the political model is derived from the suggestion that organisations do not have a singular or multiple goals with which everyone agrees and that the whole notion of structuring as a rational response to environmental and technological factors is open to question. Once the existence of diverse goals and the possibility of non-rational decision-making behaviour is accepted, the political model begins to take on increasing credibility. The process of structuring can then be looked at as a power struggle between special-interest groups or coalitions, each arguing for a structural arrangement that best meets their own needs rather than the interests of the organisation. In such an environment politics will determine the criteria and preferences of decisions. The results of this investigation provides very little support for the political model and shows very little conformance between the realities of organisational decision process and the relevant propositions. The results indicate that the interests of individuals including the dominant coalitions that control the critical resources and the interests of organisations were commonly one and the same and the top level managers acted consistently with the project objectives set by the clients and were concerned with the effectiveness of their operations and the economic efficiencies. There was no evidence of dissention and self-serving individuals determining the internal structure of their own departments or influencing such things as planning, choice of technology, evaluation criteria or allocation of rewards. In many instances the presence of environmental and technological factors imposed general constraints on structure and narrowed the choices, and after the acknowledgements of these constraints there was very little room left for either competing for control over structural design decisions or negotiating for compromises.

Organisations relied on individuals with a wide range of special skills to perform effectively, but were concerned about the influence that could be acquired through the possession of special skills and expert knowledge and realised the importance of relevant substitutes for scarce resources. Thus, their efforts were constantly directed towards the development and creation of an appropriately trained workforce whose activities could be duplicated and supervised by others preventing the indispensability of employees at all levels of organisation.

The subjective construction of reality and political motivation to support one view of a problem over other views was contrary to the findings of the research, since it was confidently claimed that although full information was never available and there was no way to determine the one best view, the project goals were unambiguous and everyone looked at the same symptoms of a problem and commonly adapted the same viewpoint about its nature and characteristics. Therefore, it can be concluded that the process of structuring is not an emergent activity consisting of conscious political decisions of individuals and interest groups and the propositions of the political model as independent determinants of decision processes in structuring are subject to questions.

In conclusion, the research reveals a reduced level of dependency on deterministic undertones of contingency theory as one of the dominant perspectives and a lack of validity in assumption of total rationality in pursuit of goals. Instead the emphasis is placed on the inclusion of less permanent and usually less disciplined dynamics of decisions processes involving the interplay of environmental determinism and strategic choice as two independent variables that are positioned at two ends of a single continuum. The interaction of these variables under the conditions of bounded rationality influence the number and forms of strategic options, the decisional emphasis on means or ends and the search activities and patterns of organisations. The integrative nature of the propositions, as depicted in Figure 4.2, provides the framework of a model that shapes and supports a process dominated by environmental determinism and strategic choice which due to its lack of orderliness cannot be systematised or formulated. Although some strategic problems, especially those that were imposed on the organisations were well structured with relatively widespread consensus as to the single best definition of the problem, most decision processes in structuring lacked a clear relationship between problem definition and best solution with no

An Integrative Model of Decision Making Process, Figure 4.2



proven alogorithm or explanatory mechanism for formulating the detailed processes.

The research contains a point of criticism that emerges from the commitment to an essentially managerialist point of view which to some extent can be partial or even misleading. It is argued that the managerialist perspective restricts the focus of analysis to specific concerns and interprets organisational phenomena in specific terms related only to the management of the organisation in question. However, the objective was not to reject the alternative point of view which suggests that the aspirations, values, interests and actions of other groups within the organisation are as important and deserving of proper attention as those of upper management, but to realise the dominant position of contract managers at the top of the organisational hierarchy. The interviews were posed from the standpoint of contract managers since they were typically connected through lines of formal authority to all parts of organisations and participated in the processes of structuring and change.

4.2 A CRITICAL REVIEW

The application of theories for the analysis of organisations have been extended in this research to include behavioural aspects of interactionism, suggesting that from a basic understanding of the nature of individual and joint action we can begin to build the ideas of social association and collective structure that are the essence of processes of structuring.

Interaction, a member's input is defined as an interpersonal situation in which the reaction of any member is a response to the action of some other member of the group. The above definition is a conventional view which regards the individual and his activity as being primarily determined by the situation or environment in which he is located. However, this thesis has adopted the perspective presented by Blumer (1969). Rather than seeing an individual who passively reacts in accordance with stimuli, external or internal, or to impersonal forces, it allows the individual much greater choice. It assigns to the individual the ability to select and interpret stimuli and to act on the basis of such interpretations. This reference to the cognitive aspects of individuals was intended to supplement the structural contingency theory.

Some writers (Morris, 1972; Winch, 1988) have suggested a different approach in which information evaluation and integration is seen as dependent upon a person's function and the decision-making process is more influenced by the social structure of the situation irrespective of the particular personalities involved. They have excluded from their assumptions the proposition that members are decision-makers and problem-solvers and that perception and thought processes are central to the explanation of behaviour in organisations.

The principal aim of Morris's (1972) work was to study how variations in the design-construction interface affect the pattern of control and coordination in the building process. In case of larger and more complicated projects, the likelihood of design-construction interface fragmentation becomes greater and thus there would be a requirement for integrative mechanisms. The nature of these integrative mechanisms depend upon the pattern of differentiation and the structural interdependence of the subsystems. Morris suggested that models designed to investigate the pattern of differentiation and integration at the design-construction interface can describe the structure of project's subsystem interrelationships and explain how changes in environmental conditions affect both the project's structure and its criteria for effectiveness.

He argued that rapid changes in commercial and industrial demands require the ability to cope with large and fluctuating degrees of uncertainty which means less emphasis has to be placed upon structure of organisation as an invariable and more attention has to be given to defining and setting up organisational relationships and their fine adjustments on a building process. His theoretical premise rejects the idea of reductionism which treats the organisation as being decomposable into elements that can be examined independently and then be aggregated to understand the whole organisational systems. Instead the adoption of a systems approach is advocated for addressing simultaneously the many contingencies and interdependencies that are present in the building process. This approach is significantly different from the present research which has focused on how single contextual factors affect structural characteristics and how these pairs of context and structure interact to explain the internal consistencies within project organisations.

In an earlier work Morris (1970) discussed the advantages of providing a system plan in order to specify the managerial and technical activities that must be performed by all the participants in the building process. The design of such a system and its implementation would contribute to the optimization and effectiveness of energy, material and information flow through the system and also the organisational relationships and managerial framework within which the project is delivered. The various influences that design decisions can exert on the system is suggested to affect both the physical characteristics of the building and the design and construction processes that are involved. Therefore, Morris argued that the system design decisions can be categorised into two different but interrelated types of decisions identified as product and process design. The product design relates to the interaction of technical decisions made within cost and time constraints, and the process design ensures that product design is accomplished in the most logical sequence possible whilst still allowing for maximum variety of the sequence as and when required. The process design specifies the technical and managerial procedures and processes required to realise product design, and hence its dimensions are organisational made around technical constraints. Morris (1970) concluded that the organisational relationships between design and construction can be defined in terms of the reciprocal feed-back that exists between the product and process design decisions.

In contrast to the above model, the present research has attempted to illustrate that the understanding of organisational design, mainly at the site level, rests both on the continual interaction of design parameters as a defining characteristic of structure, and the decision processes that represent the domain and power in the reciprocity of relationships between organisational choice and environmental determinism.

Bennett (1985) traced variations in organisational structure to environmental and technological conditions and endorsed a contingency perspective to propose a method for selection of project organisations. He relied on Mintzberg's (1979) synthesis to identify three kinds of idealized organisations in the sense that real-world organisations are unlikely to fit exactly any one of the structural configurations but are found within the defined boundaries. These are programmed organisations that provide standard systems of construction for a wide range of simple and repetitive works, professional organisations that use separate specialisations to group design, management and construction among various teams, and problem-solving organisations that are capable of sophisticated innovation to handle difficult problems outside the normal range of programmed or professional organisations. The next step in the methodology is to determine which of the three established construction methods, standard, traditional and innovative best meet the project requirements. Once an established method is identified the general nature of the appropriate organisation can be determine by references to the matching idealised patterns.

Bennett argued that the structure of above organisations are partly correlated to the contractual arrangements and client's preference for a particular management approach. The management approach can specify the management hierarchy and the subdivision of various roles, and hence the requirement for coordination devices. This argument adds a macroscopic dimension, namely the number and patter of roles as defined by management approach, to the contingency perspective. Although the present thesis has considered the impact of clients desired or undesired interferences on the environment and consequently on structure of site organisations, it has not made any reference to the intra-group relations as a structural correlate.

The relevance of systems theory and the value of its application to the organisational design of construction process is asserted to lie in the basic premise that a system is an organised combination of parts forming a complex or unitary whole. The stress is on the contribution of interrelationships of the parts of the system and the system's adaptation to its environment in achieving the objectives. Walker (1984) stated that in order to apply the system approach to the construction process "it is necessary to take as broad a perspective of the process as possible from conception of the project to completion and even beyond".

Although systems theory provide the conceptual framework for analysing project organisations, Walker saw the need in translating the concept into techniques that are useful in practice and make a positive contribution to improving management of projects. He referred to Linear Responsibility Charting as a particularly useful tool for project management, since it is capable of displaying systems interfaces and interrelationships. Its effectiveness is due to its ability to expose both the decision points in the process and the way in which the people are arranged in relation to their activities and those decision points. This charting technique is further enhanced into an analysis to provide an assessment of the degree of differentiation and the required level of integration necessary for the system to work effectively. The overall objective is to improve upon the pyramidal organisation chart and overcome the conventional professional boundaries and enable the project participants to visualise the project in terms of interrelated tasks and people rather than professional groupings.

In Linear Responsibility Analysis approach the job positions relating to various tasks, the administrative control of functions, and the coordination of activities which have a consultative nature either in the form of instruction or advice, all concurrently fit together in a relationship representing the sequence of processes. The method employed in this thesis to analyse the organisations suggest a sequential approach where the specialisation and formalisation of behaviour in performing the tasks are identified before they are put together as hierarchy of clusters. After the positions are established and the superstructure built, the lateral linkages and control systems and the distribution of decisional power complete the structural configuration. Although the design process is presented in a sequential manner the relationships among the design parameters are reciprocal.

4.3 RECOMMENDATION FOR FUTURE RESEARCH

While the identification of decision processes and the enhanced understanding of the consequences of environmental and technological influences on structure are offered as a step forward, by no means are they presented as an explanation of the total phenomenon.

Further quantitative studies aimed at the development of interaction patterns between organisational structure and performance can prove an important avenue of discovery. The focus here should be not so much on understanding the congruence between context and structure, but rather on explaining variations in performance when the environmental and technological conditions are reflected in the design parameters.

The future research provides opportunity for increased rationality and the development of predictive models embracing the following criteria:

1. Research should lead to the establishment of a link between structural effectiveness (high performance) and an internal consistency among design parameters.

2. Most statistical techniques used in the contingency research assume linear relationships between contingency factors and design parameters, however there are signs that some relationships might be U-shaped. That is, more of one variable gives more of the other only to a point, after which it gives less.

3. In case of linear relationships, a similar statistical method employed by Khandwalla (1971) using path analysis to show the covariation among the set of parameters is suggested.

   In case of curvilinear relationships, computer simulation using a discrete programming technique seems to be the most appropriate approach to produce a predictive model.

4. Contingency factors and design parameters should be measured in terms of multiple organisational activities, since studies that have attempted to select and isolate a few variables to describe the organisation often distort the reality. The future research proposes computation of composite scores on variables which are defined and measured in terms of other less significant variables.

The predictive model can help the practitioners to gain additional influence over the events and move to a relatively advantageous position where strategic choice determines organisational domain and structure, so that managerial action can mitigate against environmental and technical demands.

APPENDIX A

Case Study 1

Project Description

The project is a speculative office development consisting of 160,000 square feet of office space, 500 underground car park spaces, and 5 ground floor shop units. The building has four underground levels and five levels above the ground and is of reinforced concrete structure with reflective blue glazing for the outer skin of the building, and centres round an open square courtyard. The construction contained three distinctive phases: the foundation and substructure, the superstructure including the air handling plant on the roof, and the office fittings.

The site is located near a town centre in South East of England, and was acquired 13 years ago as small properties of old houses which eventually had to be demolished and levelled to make way for the new development. The client is an insurance group who has financed the project and who is going to let the offices, according to a prearranged agreement, to an American based food processing and manufacturing company to be used as their advertising and marketing head offices in England. Therefore, the building is going to be occupied by a tenant whose operations rely upon the use of modern communications technology and hence the building services design is one of the main features of the building. On the mechanical side, the building has a Vav system with perimeter heating. On the electrical side lighting is by uplifters and power/cabling was very much thought through for the hi-tech tenant. Supporting the Vav is an underfloor hot water perimeter heating system and this came following the decision to have a cavity floor for the cabling and the client's insistence that nothing should impede the clear glazing. The air distribution is from the atrium and the distribution ducts are transformed into major architectural features. There are terminal boxes at the inlet to the extract air system on a modular basis within the false ceiling for the purpose of having an even distribution of air. Return is through a pattern of grilles and diffusers placed more for aesthetic effect than for air distribution criteria. A number of areas, particularly the computer and processing areas, are also humidity controlled and have special fire extinguishing system.

Project Scope

The total tender price of the contract was £23.5 million and at the time of interview which was 85% completion, the project had not encountered any cost overruns. This was due to the client analysing the needs sufficiently and the designers clarifying them prior to the commencement of work on site. The design incorporated buildability making it easy or the contractor to plan procurement of materials and mobilisation on site with minimum possibility of disruptions. The client understood that any changes after the point of completed design are likely to cost, and therefore for any doubts about the finality of decisions and changes in design, special arrangements were made including the fixing of deadlines for certain changes. For building services design, the work was split between the mechanical and electrical services. Both consultants were involved at an early stage of design and both were hired for the fitting out under contracts with the main contractor.

The pre-construction time for design and planning approval took 18 months. The total construction period is expected to take 33 months. The contract specified that two programmes have to be submitted by the main contractor to reflect the work on site relating to the substructure and the superstructure. The programme for substructure which included the foundation, car parks, and plant rooms took 9 months and contained 60 activity items, and the programme for superstructure is expected to take 24 months which includes the fittings and contains 86 activity items. At the time of interview 80% of the work concerning the superstructure was completed.

Case Study 2

Project Description

The purpose of the project is to alter, refurbish and extend an existing two-storey office building to be used as the office headquarters of an international confectionery and food processing company. The office space to be refurbished is on the first floor and is 37000 square feet and the extension is for a new wing built on columns on top of a service road providing 9700 square feet of additional office floors. The contract includes a total stripout except the floor, building a new false ceiling, installing new toilets, providing a new range of rooms for meetings and conferences, a new room for computer and telephone exchange, a new access area, all the mechanical and electrical works including the fittings and finishes.

The existing offices are both large and with the inclusion of shell barrel vaults, extremely cavernous. A suspended ceiling is provided to mask these voids at a height of 9 feet. The shells are insulated and sealed externally to maintain waterproof integrity of office during construction. In order to allow daylight penetration windows are provided on 3 sides of the building. However, the layout proposed to light the central section of the offices by utilising the existing uplighters by connection to a ceiling feature using translucent panels. The intention is to focus the individual to the centre of the offices, and to further enhance this area informal office meeting and vending areas are carefully integrated into office park areas. The office parks would take the form of gardens with traditional green plants, cacti, rocks and sands.

To designate preferred circulation routes carpet colour contrasts, changes in ceiling levels, and directional lineal lights are used. All meeting rooms would be constructed of proprietary demountable type partitioning necessary in the short contract period and also to aid in future office alterations and movements.

Project Scope

The total tender price of the contract was £2.3 million and after 100% project completion it had encountered £0.2 million of cost overruns mainly due to design variations.

From the examination of the tender documents it was revealed that the client had requested the contractor to submit a price for the "shell only" of the extension, which would represent 20% of the final project value, to be followed with further negotiations for the remaining works. The contract was split into two packages to be awarded to one main contractor who had already tendered for the "shell only" work. The selected contractor was responsible for the design and construction of the "shell work" extension and for the construction management of the remaining work. The design and construct services included the preliminary investigation, architectural and engineering design, cost planning and control, and construction and site management. All the remaining works were broken down into work packages to be tendered by various subcontractors who executed their work under the overall control of the management contractor. The total design and contract layout took 3 months to be prepared, and once the main contractor's management fee and additional preliminaries were negotiated and agreed upon site activities began without any delays. The "shell only" extension work took 3 months for completion and the refurbishment which followed immediately took 6 months, with very little overlap between the two stages of the project.

Case Study 3

Project Description

The project involved the construction of a new distribution depot and warehouse centre in the West Country for a secondary client whose main business was to build distribution centres and manage the facilities on a nation-wide scale. Arrangements were made with a large manufacturer and retailer of consumer goods including men's and women's wear to rent and occupy the premises after the completion of the project. The facilities included a 15 feet high steel structure warehouse with concrete foundation providing 130,000 square feet of storage area, and an adjacent two-storey office unit providing 2000 square feet of office space to facilitate the administration of the premises. Other requirements were the construction of 400 feet of access road, an out-door parking area for cars and lorries, and fencing the site for security reasons.

Project Scope

The total tender price was £3.1 million which was kept on target by the time of completion. The contractor had not any involvement during the design phase and was not consulted concerning the buildability and the suitability of the design for speedy construction. The client appointed his own architect and engineering consultant to complete the drawings before the tender. However, any structural design given to the contractor for construction was first passed on to the engineering department to be commented upon its practicability and to be later discussed with the architect. Minor variations were introduced which were accommodated with little disruption in the programme, but they were never negotiated and never properly scrutinised before issuing the instructions causing conflicts between the involved parties.

The total construction period from the commencement on the site to completion took 8 months including two weeks of delays due to congestion in the work area at the later stages of the project. At the time of interview 100% of the work was completed.

Case Study 4

Project Description

A new county hall for the County of South Glamorgan was planned to occupy a site just outside the city of Cardiff in the dockland development area. The development brief required that the former building in the centre of the city be replaced by a more modern and spacious one located such that it would promote the development of the whole area by providing encouragement for private companies to establish themselves in the docklands. The plan for this public building included 300,000 square feet of floor space to accommodate the offices of the county council and provide facilities to host major international conferences and also having the flexibility for holding large and small commercial conferences. Other facilities to be provided were a council chamber, two auditoria, members facilities, restaurants and bars, lounge areas, and general landscaping. On-site car parking for up to 1000 cars was also to be provided.

The scheme presented did not have any restrictions on the building line to reduce the site area available for the building. However, the height was constrained by the need to align the elevation with other buildings and by environmental considerations. Thus, a resolution of the functional demand for space was achieved by providing a two-storey basement and raising the height of the building to three levels above the ground.

Project Scope

Due to the method of organising the project the management contractor was appointed at an early stage to integrate procurement, planning, and site preparation and generally widen the range of construction expertise available to the client. The project tender included the management fee and the cost of other services such as applying management skills and techniques to the organisation to control all the aspects of the project jointly with the architect on behalf of the client. The contract value was £24 million which included the contractor's fee and his services as the client's joint project manager on site. At the time of interview 80% of the contract by schedule was completed and the programme had encountered 6% cost increase due to amendments and additions to the initial scope of the work.

After award of the contract the management contractor began the preparation of work packages which included the design and details for tender. Majority of packages were prepared in this process and were completed 16 months into the programme. The site preparation commenced before the start of actual work on site and included activities such as site establishment drawings, investigation into the use of computers, updating the design and construction programmes, interviewing and inviting contractors to tender, manufacturing and erecting site signs, preparing site offices, and placing orders for various items like safety clothing, stationery, photocopier, rubbish skips, canteen facilities and operators, first aid, and telex and telephones. The site preparation began one month after the preparation of packages and required 6 months for completion, after which various specialist contractors mobilised on site and the construction activities commenced.

The site activities and construction were planned to take 29 months and including the overlapped period for packaging and site preparation the total contract was 33 months.

The general notion to accept management contracting was that it is a correct prescription for fast-track construction and it has a reputation for speed and flexibility. However, many amendments and additions were incorporated into the master programme, which contained 46 work packages, and ultimately resulted in 3 months of delay.

Case Study 5

Project Description

The contract concerned the refurbishment and partly rebuilding of an old office building in a busy district of central London, to provide the total of 45,000 square feet of office space. The main contractor identified the following activities as major elements of the work: the main core of the building had to be taken out and replaced by a lift and the deteriorated concrete structure had to be reinforced; the foundation required strengthening for construction of two more floors on top of the building and a plant room for an air-conditioning unit in the basement; the increasing traffic noise demanded double glazing and hence air-conditioning; there were no internal partitions but lobbies and toilets were installed throughout the building; the water-supply distributing pipes and waste and drainage system together with the plumbing fixtures were all replaced by new ones; the site was in a congested urban area with similar adjacent buildings of four storey reinforced concrete frame on piled foundations and precast concrete flooring, therefore the structure had to blend with the existing facades with exterior surfaces coated stucco and interior walls plastered and painted.

The client was a property developer who would sell or let the building according to the market conditions, and therefore the speculative aspect of the contract had to be taken into consideration by the client in setting targets.

Project Scope

The tender price of contract was £1.15 million but after the inclusion of additions and variations by the client, the final price totalled £1.3 million. The pre-construction time, including the design phase, took two years which began after the property was acquired. This phase began by the client's first specific move to appoint an architect with the objective of designing and costing the project and producing the conditions for site work. The relatively long pre-construction time was caused by financial uncertainties and obtaining planning approvals.

The construction took 18 months to complete, including the finishing work, and took six months longer than the original estimate. The designer did not sufficiently clarify the client's needs and thus throughout the project he called for a significant amount of additions and variations which added to the cost and delay. The design did not incorporate buildability and proper planning for procurement of materials and movement of various trades on and off the site for minimum possibility of disruption. Delays were frequently caused by problems connected with the site which were discovered only after work started, and were connected with conditions of the structure and obstructions and congestions. For example, revision in the design of foundation became necessary after excavation revealed the actual state of the ground. The design of structure and major components of the building was carried on as the construction was proceeding. Thus, in some instances the main contractor had to wait for the design to be completed and lack of full communication between the client and the designer slowed down final acceptance of the completed design. In many instances doubts remained about the finality of the decisions since the whole process of design and construction was dependent on the findings of the construction team on site about the conditions of the building.

Variations also emerged as one of the important causes of delay, and in particular the delays arising from the need to get new decisions were more significant than the delays arising directly from the changes in the building work. The contractor believes that minor variations could have been accommodated without disrupting the programme, but there should have been an attempt to deliberately delay some of the detailed decisions at the design phase for incorporation into the project programme.

Case Study 6

Project Description

The project is a relief road, built for one of the county councils near the southern coast of England, to bypass and divert traffic from a town centre to reduce congestion. The road is 3km long and 7 metres wide which carries two traffic lanes and goes over 3 subways and 3 fully supported concrete bridges. The road also contains 5 manholes and 2 roundabouts.

The main contractor identified the following list as the major elements and activities of the work: setting out, earthworks including site clearance and topsoil strip, fencing, building site offices, drainage system including the import of free draining granular fill, sub-base laying and surfacing, piling, soffit formwork, structural waterproofing for the underpasses, parapet railing, construction of footbridge, bridge joints, wing walls and sidewalk retaining walls, bricklaying to facades and connecting walls, excavation of waterway and beam erection and structural work for the bridges, kerb laying, electrical work including gullies and ducts for street lighting cables, and hydrosecting.

Project Scope

The tender price of contract was £5.227 million but due to certain delays and disruptions and also variations introduced by the client, the final price was £5.363 million. Delays and disruptions were due to increased quantities of refuse excavation and backfill, together with the earthworks delays, due to bad weather, encountered earlier in the programme. Thus, the knock-on effect of this forced drainage, roadworks and surfacing behind programme by seven weeks. Although delays due to unfavourable weather early in 1986 generally resulted in roadworks activities as a whole to run seven weeks behind expectation, since then very favourable weather conditions had permitted continuous earthworks operations throughout the contract period. Other extra works which influenced the time and cost of the programme were caused by client's variations in earthworks and disruptions arising from site instructions.

The design responsibilities were with the client's engineering consultants, and though the main contractor was not aware of the total design period, it was expressed that since the area is environmentally sensitive, and the design required considerations for the visual effects on the environment the design period was rather long. The construction commencement till completion took 22 months of which number of weeks late relative to original contract was 24.

Case Study 7

Project Description

The project concerned the extension and alteration of a superstore which had become increasingly run-down and deemed unprofitable by its owner. The owner was a limited company operating one of the largest chains of superstore on a nationwide scale. The existing building was a single storey steel structure with concrete foundation and had a total of 20,000 square feet of ground floor space. Apart from the refurbishment of the live business premises where the client's business had to be maintained, the contract included the extension of the sales area, the extension of the foyer and the kiosks, a new training room for the new employees, a preparation area, and a new bakery.

Project Scope

The total cost of the project including the variations and alterations of the design and the cost overruns due to delays was £1.7 million. The price submitted was based on the approximate bill of the quantities and although the production information at the start of the project was incomplete, it was sufficient to begin work as soon as possible as required by the client. The architect and the specialist designers maintained a constant rate of information which contributed to a smooth and efficient progress of site activities. The contract, which encompassed all the finishing works, contained two sections. The first section was programmed for 20 weeks and included 42 major activities for the alteration and extension of the building and the establishment and set up of the site offices. The second section of the contract related to the works on the refurbishment of the existing offices, the refurbishment of the restaurant and construction of a new cash office, and was programmed for 12 weeks to be commenced immediately after the first section of the contract. However, the latter part of the project overran by 2 weeks since the restaurant was not available for access.

Case Study 8

Project Description

The project was to provide a new prison for the Home Office, requiring the accommodation of some 400 inmates to be housed in both single and double cells. The client brief also demanded the full usage of the existing prison estate which meant that the new centre had to replace an existing structure. The plan consisted of a cruciform shape cell blocks with common accommodation and services block at the centre, and split by a secure first floor link with no movement at ground level. The enclosed link gave access to a service and administration complex, workshop, hospital, and sports facilities with a large playing field. In-cell sanitation was provided, designed in such a way that occupants could be kept under surveillance at all times. The common core in the accommodation blocks, provided modern and secure control room so that prison officers could see and monitor all the landing areas. On the line of the perimeter wall was the entry building through which all pedestrian and vehicular traffic was channelled to and from the secure establishment. Located outside the wall were the staff social centre, visitors reception centre and car parks.

Project Scope

The project was part of the Home Office prison building programme which was funded publicly with the tender cost of £7 million. However, since the interview was conducted at the very early stage of the programme, approximately 10 per cent completion, accurate information on possible cost overruns was not available. The main contractor was not invited for an early involvement in the planning and design to offer his expertise and to help in achieving a design incorporating buildability, and therefore he was not aware of the pre-construction time including the design process. The project was provided by the PSA as the agent to design and manage the work on behalf of the client. The construction time from mobilisation to completion was programmed to take 30 months, and since at the time of interview 3 months had only passed from the start-up time, it was difficult to make any accurate assessment concerning the possible future delays due to variations or extensions in the scope of the work.

Case Study 9

Project Description

The brief required a new prison to be built on a green field of approximately 50 acres providing a site area for development significantly higher than the normal site requirements for new prisons. One-fifth of the field was formerly occupied by a youth custody centre which was demolished as part of the plan and in order to avoid building over existing foundations the vehicular compound and the artificial football pitch were planned on those areas.

There were 11 two-storey high buildings divided into two main cell blocks. All the cells had integral sanitation and were arranged around two-storey association areas separated by central observation offices. Prison support facilities included an amenity block as a communal building for chapels, library and educational facilities. There were also an observation and assessment unit, one main workshop, buildings for medical needs and physical recreations, reception and discharge areas, kitchen and central administration offices. All the facing materials were bricks with contrasting brick window cills, heads, plinths and string courses. The roofs were pitched and were developed with a consistent vocabulary and covered with proprietary profiled metal roofing.

The complex included a farm and a small garden building, a main boiler house with a booster station. The cell blocks provided 13,000 spare metres of accommodation and the rest of the buildings provided 13,000 square metres of floor area. On the line of the perimeter fence the entry building was located through which all pedestrian and vehicular traffic could be channelled to and from the secure establishment. Outside the perimeter fence a perimeter road was constructed and was connected by a half-mile access road to the main road. The large site allowed for the usual mounding and screen planting commonly associated with the perimeters of new prison sites.

Project Scope

The project was part of the Home Office prison building programme which was funded publicly with the outturn cost of £21 million. Cost estimates were prepared and revised at many stages throughout the development of the project and the estimates presented contained the most probable value and achieved a high degree of accuracy due to clear definition of the work for the contract at tender. However, the final cost of the project was approximately £1.0 million more than the tender price caused by the effect of inflation which was not uniform throughout the various trades and for materials.

The new prison programme, provided by the PSA Design Office, was initially shelved for three years due to a moratorium. At the end of the moratorium the PSA was instructed to continue with the project, and together with the design team spent 10 months to provide the outline design. After the contract was awarded, four weeks were spent on the contract preliminary planning to determine the main constituents of the work and prepare the documents including the master programme and the schedules. The total construction period was 30 months which began with the construction of a permanent road to provide access to the site.

Case Study 10

Project Description

The development brief required the construction of a modestly-sized office block consisting of seven storeys of which two floors were below ground and providing 30,000 square feet of office space. The building was of steel-framed structure with concrete floors and brick walls and in order to match the neighbouring buildings the front and rear elevations were decorated with stucco rendering and hardwood sash windows. The building occupied a site which was hemmed in on two sides by existing buildings and was vacant for several years until after a period of uncertainty over the use of it the corporation of the City of London acquired the land with the intention of developing a prestigious office block.

Project Scope

The contract was obtained through competitive tender with the initial price of £5.48 million. However, due to the introduction of minor variations and the problems caused by ground conditions, the project experienced cost escalation amounting to £0.52 million. The construction works contained 140 activities and 9 distinguishable phases and began, after 3 weeks of mobilisation, with the preliminary works of underpinning and erecting shores and establishing the site office, and continued with the substructure, superstructure, mechanical and electrical services, finishes to office areas, finishes to toilet areas, finishes to stair areas, finishes to entrance hall, and the external works including the local authority paving and service connections. The project was planned to be completed in 20 months, but the variations and cautionary approach in performing the substructure activities over-stretched the overall schedule by 2 months.

Once the preliminary brief was obtained and the design completed, the client's project team proceeded with obtaining some of the necessary statutory consents for planning permission and building regulations approval and to make sure that the development plans were according to the local authority development plans and requirements. However, since the scheme was not controversial and did not cause any conflict between the interests of the client and the community, no public inquiry was needed and the basic procedures at the design stage were followed smoothly in the shortest possible time.

Case Study 11

Project Description

A Grade II listed building, located in Central London, was purchased by a newly established property development firm and a residential solution was pursued as a viable use for the premised to be refurbished and converted into a block of luxury flats. Planning permission was obtained from the British Heritage to demolish the rear of the building, including the substructure, and preserve the front exterior and the front rooms which occupied one-third of the site. The exterior of the building had to be renovated most sensitively in such a way as to maintain the outward appearance, without removing any major structural elements and by adding only a few trimming pieces. These included the renovation and replacement of the windows and canopies, the roof which was of steelwork, and the reinforcement of the substructure. The design intended to provide 19,300 square feet of floor space, evenly spread among the seven-storeyed building, including the basement where the plant room was located.

The two sides of the listed building were constrained by the adjoining residential blocks; to the front a busy through road, and at the rear a terrace row of mews houses facing a quiet and narrow street. The building was separated from the mews houses by a void which was to be landscaped into a courtyard. The mews houses were also purchased as part of the property and since they were relatively run-down, the project included their total demolition and construction to provide an additional 3,000 square feet of mews flats.

Project Scope

The project as a private speculative development was funded directly by a financial institution and the financing arrangements covered the full cost of the project including the purchase price of the site. The client's objective was to maximise the return on the investment in the shortest period of time, and in order to save time the main contractor was selected by negotiation and not by tender and was urged to organise and prepare for the project and programme the work with the subcontractors as soon as the contract was awarded. The contract with the total value of £2.0 million was divided into two sections, consisting of the demolition contract with the period of 2 months and the new building contract which was planned for 16 months. The main contractor assessed the contract thoroughly and accepted the risk of starting the demolition work 5 days before receiving the letter of intent, and therefore set a fast pace from the outset to meet the client's requirements. The construction phase consisted of two main operations which were programmed concurrently to build the main block and the mews flats, and contained 70 site activities including the garden works.

At the time of interview, 20 per cent of the work was completed such as the demolition of the rear of the building, the underpinning of the adjacent structures, the placement of the foundation, the work on the temporary services, and the preparation of the site office. Also, the reinforced concrete was at the second floor and the brickwork was in progress.

Case Study 12

Project Description

The project involved the construction of a shopping precinct within the boundaries of a major residential development in London's docklands with the aim of providing convenient shopping facilities for the local residents and accommodating a new retail market that was envisaged to be created by the completion of the surrounding developments. The contract was owned and initiated by a large supermarket retailer who had the intention of occupying 70,000 square feet of the premises and letting out the remaining 230,000 square feet to various retail businesses. At ground level along the facade of the building, 30 shop units were introduced as fashion outlets which were linked up inside the store to form an arcade leading to the main entrance of the supermarket at the one end and to the main entrance of a department store at the other. The department store took a pre-letting of 60,000 square feet of space which was designed to fulfil the specialised requirements of the tenant.

A great deal of landscaping was incorporated into the works, and outdoor parking spaces for 1,300 cars, a restaurant and a petrol station and other ancillary facilities suitable for a modern shopping centre were to complete the development.

Project Scope

The client had decided to negotiate the contract in two stages separating the fitting-out from the rest of the activities to enable the contractor to make an early start on site and to allow the tenants more time for firming up their requirements for internal arrangements and services. The value of the contract was £21 million. However, due to the inclusion of the landscaping as a major design feature and the extensive tenant's modification of fabric and services, the cost of the contract was escalated by £3 million during and up to the first 8 months of site activities.

The client spent two years to acquire the land and to initiate the design work by the consultant engineers in co-operation with the architect. Also, during this time a certain amount of earthwork was carried out by the main contractor, since 30 per cent of the land was submerged in water from the river Thames and prior to site mobilisation it was necessary to separate the land from the river by constructing a coffer dam and pumping out the water for a compacted fill. The contractor commenced work within 7 days of notice and was anticipating to meet the planned completion date which provided 20 months for the whole construction programme.

Case Study 13

Project Description

The principle of improving the North Wales Coast road for the needed relief was established by the Welsh Office, and the plan called for the conversion and development of the existing road system, a distance of 43 Km, into a dual two-lane flexible carriageway in accordance with standards of the Department of Transport for the purpose of coping with the generated traffic and the possible future change in travel mode. However, the contract referred to in this discussion was only a section of the total road improvement scheme and involved the construction of a new two-lane coastal road along the hillside for a distance of 3 Km in parallel with the existing single two-lane carriageway which was improved and retained for the west-bound traffic. The new road included a tunnel which stretched for half a kilometer through the headland of various but mostly rocky terrain before it emerged in the west and carried the new road to a roundabout to connect the system to the present radial routes.

In order to widen and improve the existing carriageway a significant amount of side-road construction was required which included retaining walls with structural drainage to reduce the hydrostatic effects, the reinforcement of embankments, and the pavement for a pedestrian footpath along the coastal road. A great deal of gravel was placed in the shoulders to some of the steeper embankments and was dynamically compacted and drainage blankets and a capping layer were placed beneath the pavement construction to satisfy the requirements of a free drainage specification. The ancillary works for a system of surface water drainage was partly formed by traditional carrier drain and gully construction. Besides the main drainage provision, a valve switched system was required within the tunnel to collect seepage and carried-in water as well as the run-off from maintenance washing. The contract also required the installation of extensive lighting facilities which took the form of continuous catenary system and a fully comprehensive network of communications equipment which comprised of cabling for emergency telephones, signalling and detector loops.

Project Scope

A considerable amount of time was spent on proposing alternative routes and conducting a comparative evaluation to identify and select among the three feasible corridors. The process of route identification which was based on economic analysis and environmental assessment and the additional studies commissioned by the Welsh Office to investigate the technical, economic and environmental feasibility of the scheme took approximately 4 years to complete, after which the Inspector's report and recommendation was reported and the final decision was made by the Secretary of State. The technical and aesthetic design of the road which was to produce a scheme of visual quality and in sympathy with the existing coastal landscape and urban environment was handled jointly by two firms of engineering consultants over a period of two years.

The project was constructed under two separate contracts. The main contractor was awarded the first contract with the tender value of £11.5 million to undertake the site clearance and topsoil strip, temporary works including fencing and gates, civil works for tunnelling and road construction, highway furniture and opening the routes to traffic. Due to delays caused by adverse weather conditions and additions to the contract requirements and variations, escalated the tender value by £0.6 million and extended the initial contract duration of 24 months by another 6 months. The second contract was awarded to a mechanical and electrical contractor to undertake the installation of road and tunnel services under the direct supervision of the client. These works were required to be carried out in phase with the civil works at the later stages of the civil contract and after the completion of the civil works by the main contractor. The equipping of the road and the tunnel took 11 months after which the main contractor took over the site again to do the finishing parts and directing the traffic through the new system and to hand-over the project.

Case Study 14

Project Description

The continued growth in air transport and the increased demand for additional airport capacity in the South East area, promoted the long-term expansion and complete redevelopment of an existing airport to cater for short-haul and long-haul traffic and provide additional passenger handling capacity in time to meet future demands. Hence, the international airport, handling over half a million passengers a year, received outline planning permission for the development and maximum use of land available within the site area to meet the requirements of commercial services and increase the capacity to about 8 million passengers a year by the completion of the project which was planned to take 6 years. However, it was considered that the project was too large for a single national contractor and thus the work lent itself to being divided into separate contract work packages of various sizes. The contract discussed in this report relates to the construction of additional apron, taxiways, and turnoffs to provide access to the terminal's aircraft stands, and the installation of high intensity inset lighting to the standards required by the Civil Aviation Codes of Practice. The aprons and taxiways were constructed of plain slab, unreinforced, undowelled pavement quality concrete for unlimited use by all types of aircraft. The substantial increase in airside and landside paved surfaces required the design and installation of a new drainage system to accommodate a five-year storm frequency. The works included 5,000 metres of surface drainage (150 mm - 975 mm diameter) and 3,000 metres of french drainage (550 mm diameter) together with several in situ reinforced concrete box culverts at taxiways.

Project Scope

The consultancy arm of the British Airports Authority was appointed to undertake the development study and provide the outline design for the expansion scheme to accommodate the future traffic of mostly international short and long haul services and the handling of 8 million passengers per annum. Steps were taken towards the major development of the airport, since marginal improvements could not have ensured the maintenance of an effective range of air services and the reduction of congestion, leading ultimately to traffic transfer to other airports and causing an unacceptable situation. The scope of the project had to satisfy the criteria that all land required for development should be readily available, future development beyond the immediate planning horizon should be possible if traffic warranted it, modern and efficient facilities should result from any development scheme, and the cost should be in line with the future role of the airport.

In order to compress the project duration, the accelerated delivery approach of fast-tracking was adopted for the majority of the work packages. However, for this particular contract the design and construction activities were not overlapped and the detailed design was provided which enabled the contractor to submit his price based on full bill of quantities. The total cost of the project, including a small escalation, turned out to a final figure of £7.2 million which was picked up by a local civil engineering contractor for completing the package in 16 months in accordance with the programme requirements.

Case Study 15

Project Description

A major structural work was required for the maintenance and strengthening of the Severn Bridge and the Wye Bridge which are part of a permanent roadway crossing just above the confluence of the Severn, the narrowest stretch for some miles upstream or down. The overall length of bridge-work extending in a straight line from the west bank of the Wye, over the Beachley peninsula, to the east bank of the Severn is 9,817 feet. At the time of the design of the bridge and its associated motorway system, the navigation authorities required a clear opening of at least 3,000 feet and a clearance of 120 feet above the high water, and therefore stipulated a suspension bridge as the obvious solution. With the east pier founded on its rock outcrop, a 3,240 feet centre span located the west pier in a position on the Beachley shore satisfactory to the navigation authorities, where it could be founded by open excavation in cofferdams to solid hard marl about 30 feet below the river bed, 50 feet below mean tide level. Two 1,000 feet side spans brought the east anchorage on to the other limestone outcrop and the west anchorage to the dry land at the Beachley peninsula. To the west the river Wye was bridged by a cable-stayed girder with 770 feet main span and two 285 feet side spans, and between the two bridges the road was carried over the peninsula on a steel viaduct with the length of 3,200 feet, at an average height of 50 feet above the ground level. To the east a continuous structure of three-span viaduct totalling 515 feet reached from the main bridge abutment to a cutting in a 150 feet high cliff.

The bridge-work carried the motorway as dual 24 feet carriageways separated by a median strip, and catered for the local need by a 12 feet cycle track on one side of the motorway and a 12 feet footway on the other. The deck was an in situ reinforced concrete slab 8 inches thick connected to the steelwork by welded studs for composite action in resisting bending movements both longitudinally and transversely. The concrete deck was sealed with bitumen and surfaced with 1 1/2 inch of mastic asphalt on the roadway and a double dressing of rubber bitumen on the footway and cycle tracks. For aerodynamic stability the design of the deck was of hollow box girder with a streamlined surface to produce a continuous outline without kerbs or other obstructions that would disturb the smooth flow of the wind. This led to the use of a handrail at the outer edges and crash barriers formed of four lines of stretched steel wire strand at the sides of each roadway. The omission of the traditional kerbs on the deck had the practical advantage of allowing a broken-down vehicle to draw close to the barrier, thus providing the minimum obstruction to the traffic.

The design of foundation for the main towers was sufficiently large and massive to be immovable in case of impact from floating objects travelling at the speed of rapid current. Each pier was therefore solid concrete, and sufficiently long to support the bases of two tower legs 77 feet between centres and 445 feet high above the water level. The design of each tower leg is a simple rectangular tube formed from four stiffened plates. The use of this form, facilitated by the great reduction in lateral wind forces to be carried, was far more efficient in use of material than cellular construction.

Project Scope

The cyclic stresses and the appreciable damping effect of many joints in the structure and the longitudinal movements of cables relative to the deck had introduced an element of fatigue into the structure of the bridges over the Severn and the Wye rivers, requiring a major repair and strengthening operation. The work included the stiffening of the tower plates and replacement of the saddles at the tower tops which weighed about 26 tons each and were of composite construction with specially shaped cast steel grooves welded into the structure. The inclined suspenders, which consisted of single strands of spiral lay rope attached by cast steel sockets at either end and pinned to the cable bands and suspender lugs, were also replaced. The actual welding procedure for the main joints was the subject of some experiments and it had been anticipated that it would be possible to use mechanised welding for the greater part of the 25 miles of welding work. All the exterior surfaces of the steelwork in the towers and the suspended structure were grit-blasted, metal sprayed and painted with one coat of etch primer followed by a three-coat paint treatment. All the interior surfaces of the towers and the suspended structure were painted with two coats of red lead. Although there were some deck improvement works, the resurfacing of the pavements was not part of the contract and it was postponed to a future date. The project also included the supply of fixed gantries for future inspection and maintenance.

The engineering consultants employed by the Department of Transport carried out 90 per cent of the design work over the period of four years and provided the detailed design of the whole structure for the repair operation. The main contractor was only involved in three topics of the design which covered the remaining 10 per cent and took 6 months to complete. The total construction period was 2 years and the project encountered a limited number of variations amounting to only 2 per cent of the total contract value of £30 million.

Case Study 16

Project Description

The project is the new British Library building, which is located on the former Midland Railway Goods Depot, and is Britain's first purpose-built national repository for up to 25 million documents ranging from priceless historic manuscripts to a near-comprehensive worldwide trawl of new publications. The new building, under PSA's direction, intends to bring together most of the library's functions under a single roof and to supercede most of the 19 premises around London currently occupied by the library's various collections including the National Sound Archive and some volumes housed by the Lending Division in Yorkshire. Due to recent budget cuts the Indian Office library and records have been excluded from the centralised facility. The plan involves the construction of deep basements to house the books, reading rooms for humanities, science and technology collections, preservation workshops, exhibition galleries, lecture theatre, meeting rooms and offices, catering facility and a courtyard. A fundamental feature of the building is its free and adaptive form of architecture rather than the fixed symmetries of classical form. The external facet consists of cladding in red brick, and takes an asymmetrical broken form, with slate pitched roofs and metal and granite weatherings.

The design of the building is affected by the requirement of the users and the two types of readership; those needing access to the humanities collection, stored in the basement, and those using the science and patents collection where the books would be available in the normal way on the shelves and on microfiche. Between the reading rooms there was the main entrance hall from which access was gained to all the public areas, including the exhibition galleries and the multi-level bridges which connected the science and humanities collections. The books would be stored in the massive underground basements with 180 miles of shelving accommodated on a mechanical shelving and retrieval system similar to that used in warehouses. The book storage had been pushed underground to release the upper daylight levels for reading rooms and exhibition halls. The underground storage area comprised the largest basement in London for civil usage and had four cavernous floors descending to a depth of 25 metres before ground level and stretching the width of the block.

The new building was set back from the surrounding roads by an enclosed forecourt, screened by walls, railings, trees and an entrance portico, protecting it from the noise of traffic in Euston Road and Midland Road.

Project Scope

The plan for the current building was approved by the Government in 1980 and the entire library, which is the PSA's largest civilian project is scheduled to be completed in 1996 at a cost of £400 million. The criticism of the project revolves around the protracted development programme which can be explained partly by the sheer size and complexity of the building, most of which is underground, and partly is dictated by the releasing of funds in limited yearly increments, which has resulted in a confusion of overlapping phases and sub-phases. Given the circumstances, all the parties involved agree that the project is still running largely on schedule. However, there has been a slippage of some five weeks in recent months, due to slow mobilisation of the site operatives by the contractor in charge of the brickwork in the basement, which is planned to be recovered within the next six months from the time the interview was conducted.

The Government has avoided making a commitment to the whole structure as it was originally envisaged, and has curtailed the project by developing a smaller building, mainly because of changing technology which for example has meant that the huge catalogue hall would no longer be necessary with the use of computers, and by disposing of the residual part of the former railway warehouse site. However, the disposal is not anticipated for some years until the library defines its access requirements. The curtailment of the project is also attributed to the ability to out-house the storage of publications that had originally been planned for the site.

The preliminary phase of the project related to the civil engineering works which took place between April 1982 and October 1987, with work starting on the superstructure well before the basements were completed. The preliminary works included the sinking of the perimeter retaining wall to a depth of 30 metres, concrete pile for the structural columns at 7.8 metre centres, and the top down construction of the basement with floor slabs each 0.4 metres thick.

The whole of the first phase, which by the time of the interview was well under way and contained 200 parcels, was authorised in 1986 and the master programme, outlining the five main operations of structures, envelope, basement finishes, superstructure finishes, and external works, was approved by the PSA in June 1987. The first two phases of the project, with the cost of £270 million, were not scheduled for completion until the end of 1993. After completion of a feasibility study by the consultant architect, it was decided to give the go-ahead to the £90 million development of one single concluding phase. The back wall of the first phase, facing out across the rear of the site, is temporary and that is where the the completion phase will be added on. The detailed design work remains to be done, though a feasibility study has been conducted and the major practical constraints have been reconciled with the client's brief. The completion phase will allow the transfer of the remaining reader seats from the British Museum and its curatorial staff and increased access provisions for the Scientific and Reference Information Service.

Case Study 17

Project Description

The project is office block speculation on a stupendous scale providing large expanses of state of the art modern offices and dealing rooms, for international finance houses, at the eastern edge of the City's Square Mile. The development is entirely created from under-used railway land and is located on the site of the former Broad Street Station which was demolished and its train services diverted to the larger Liverpool Street Station next door. Including the deal with the British Rail Property Board to bring about major changes and improve the Liverpool Street Station, the project amounts to 14 major office blocks, which are constructed and delivered in phases, covering some 12 hectares of land, some newly created over the railway tracks, and providing 500,000 square metres of office space to serve the 2,500 projected occupants of the development. Also, there are passenger concourses and a bus interchange to serve the station as well as the buildings and at ground level shops and restaurants and an arcade linking the offices to the railway station.

The focus of investigation is the first four phases of the project which consist of four eight-storey office blocks with facades of protruding pink granite fins and screens which enclose the two outdoor squares and provide a total of 175,000 square metres of office space. The rest of the phases to the north and east surround Liverpool Street Station on two sides and are comprised of twelve-storey buildings with facades of pink and grey granite and bottle-green glazing.

The new buildings are designed to reveal all their vocabulary to the streets and are concealed behind a grid of granite which divides the facade into smaller elements to reduce the impact of the scale of the buildings. The fabric is composed of curtain walling using 6 square metres prefabricated and pre-glazed panels. Pink and grey granite, bottle-green colour coated aluminium mullion and matching green tinted glazing are modulated to give an effect of solid load-bearing masonry to the lightweight steel-frame structure. Dealing floors are located at lower levels, with 20 metre wide column-free floor plans above. The lofty storey heights of 5 metres from slab to slab are designed to accommodate raised floors and suspended ceilings equipped with electronic servicing to a record intensity of $200W/M^2$, and air conditioning ducting. To provide visual relief for office users, the deep-plan office floors above the dealing rooms are punctuated by light-filled atria, sometimes as many as three in a single block, and lavish entrance lobbies as part of the basic shell and core package. Each block has two lobbies; a double-storey marble-faced public lobby at pavement level, and the company's hardwood panelled reception at first floor level.

The main square is paved in travertine and is dominated by a large horseshoe-shaped enclosure four storeys high. The enclosure is raised above the pavement level by a colonnade rising out of a smooth marble floor, and the circular open wall around it supports trellises of plants. Once completed, the entire development will contain in aggregate three major public squares and a network of minor civic spaces. All external floor and wall surfaces are made up of tactile natural granite and marbles in a variety of smooth and textured finishes, and the public spaces are further embellished with seats, greenery, fountains and specially commissioned sculptures.

Project Scope

The scheme, at the north-eastern limits of the City, is a £800 million modern office block development by an international property developer in partnership with the British Rail Property Board. As the result of intensive research of 60 typical tenant companies and 11 comparable office buildings, carried out by space planners, the design of the shell and core to provide 500,000 square metres of office space is accompanied by all the requisites of upmarket offices for the financial sector.

Due to the speed of construction, the first four phases of the development, having a total of 175,000 square metres of space, were completed three years after the commencement on site, including the tenant's fit-out, while phases five to eleven were at various stages of construction. The foundation for the next seven phases which run along the east side of the Station and extend over the platform in the eastern train shed were already under way. At the time of the interview, other phases were still subject to further deliberations between the client and British Rail. The first two phases, each of the large eight-storey office blocks, took only 12 months from start of foundation to handover to tenants, consuming around 2 man-hours per square foot. The major steelwork for phase three was erected in only 4 months. The average construction spending during the early phases was running at over £1.0 million per week, but at peak it is expected to top £20 million per month.

Although it was an extremely busy cosmopolitan site, with architects specifying Dutch, West German and Italian cladding systems for the fast-track project, and an average of 350 subcontract operatives working on site each day, the construction manager was able to complete the £150 million scheme on time and within 4 per cent of the cost plan. This figure excludes the cost of the fitting out operations, which the prospective occupants chose their own designers and management contractors to carry out, amounting to £240 million.

The open squares and civic spaces and other artistic and social amenities were all pre-ordained in the developer's master-plan. As well as serving the 25,000 projected occupants of the development, these amenities are accessible to the public. The dominant matrix of office blocks is underlaid at ground level by a network of shops, pubs and restaurants. Office tenants have been persuaded to accommodate shops and restaurants on the ground floor of their premises, and retailers dissuaded from bunching together next to the station. The intensively used public spaces are kept free of litter and vandalism by the efforts of 50 management staff, security guards and cleaners, all employed by the developer. The developer's plan to convert as much railway land as possible into offices required extensive rationalisation of the entire interchange of Underground, buses and taxis to form a £60 million transport interchange.

Case Study 18

Project Description

The client's brief required the installation of a new plant within an existing pharmaceutical factory compound to increase the penicillin production capacity and the modification of an existing fermentation plant to an alternative process. The project also included the modification of services equipment to support the expanded facilities and an additional solvent recovery plant with the associated tank farm and the sub-station to support a proposed new extraction plant.

More specifically, the project contained five main packages. The chilled water system with 21 items of equipment including the chilled water tank on prepared foundation and steelworks. The penicillin building with some 82 major items of mechanical equipment including two fermenters, a surge drum, a new package sub-station, and extensive modification to the existing control panels. The clavulanic acid area consisting of 12 new items of equipment including a homogeniser, sterilisation vessels, and an arkasoy unit. In addition to the equipment installed for the chilled water system, as part of the utilities package a further 6 items were later installed including an air compressor and a carrier centrifugal liquid chiller unit which required the removal of a section of the utilities building end wall to allow the unit to be slid into position. The final package was the expansion of the solvent recovery plant which consisted of 94 items of equipment including 38 pumps, 19 tanks and a solvent recovery sub-station. The recovery area was designated as a hazardous area and no hot work was permitted and all the drilling and welding had to be carried out off plot. The fire protection system was extended to cover the new process unit and the tank farm.

The associated works for various packages included concrete foundation, building works, structural steelworks, scaffolding services, piping and piping tie-ins, insulation, painting, electrical and instrumentation, mechanical installation, and a new fully equipped laboratory.

Project Scope

The expansion scheme was conceived by the client well before the actual work on site began and the contractor who initially built the plant, was constantly consulted and carried out studies and reviews of performance to evaluate energy conservation, application of new equipment and techniques and the revision of process routes to increase production output. The contractor produced the design specification and set up a process task force composed of personnel from the client's operations department and his own process engineers as a fact finding team. The task force collected historical data, inspected reports and existing drawings, and surveyed and verified the drawings of underground piping and electrical cabling. The objective was to achieve the optimum fit of new equipment into the plant in accordance with the client's process requirements. After completing the conceptual design the task force then developed the process design in more detail. Using data from the site survey and plant audit, and based on the optimisation studies a revamp process flow diagram was developed which was carried out on the whole plant and not just the portion to be revamped. Also, a report sheet was prepared for all the existing equipment giving details of the changes required such as new nozzles for vessels and impellers for pumps. The revamp process flow diagram was used as a document for review and reference through to commissioning and startup. Two other sets of diagrams were produced which contained the demolition and installation diagrams.

At an initial stage of the design a hazard and operability review was conducted since revamps are potentially more hazardous than a new plant. This review was repeated at the completion of the design and was held at site as part of the checkout of the plant prior to any restart after the shut down.

Finally, to prepare a scope definition, a revamp execution plan was prepared and broken down into all the disciplines including civil work and foundation, building, structural work, mechanical, electrical, H.V. and A.C., piping, instrumentation, insulation, painting and fire protection. These disciplines were split into five main areas of development and were grouped together in various work packages which were contracted out to 30 trade contractors. With the information available in the execution plan, evaluations were made for a preliminary overall cost estimate and a preliminary estimate of shut down duration. After the production of the design specification and the cost estimate, the client sanctioned the revamp and referred to the same process engineering contractor to proceed with the project. The client's objective which reflected the highly investment sensitive nature of the development was successfully met and the construction activities including demolition, installation and commissioning were completed within the planned duration of 24 months. The final cost of the project with an insignificant amount of escalation due to design variations added up to £15 million.

APPENDIX B

B.1 Interview Guide

This section provides the basis for data collection concerning the structuring of organisations and building the agenda for conducting the interviews. The descriptions of the projects are discussed first by identifying project purpose, scope and contract delivery systems. The environmental and technological conditions of each project is independently discussed to determine the corresponding dimensions and hence the implied structural characteristics. Finally, four design parameters consisting of design of positions, superstructure, lateral linkages and decision-making systems and processes are investigated to reveal the actual state of site organisations.

B.2 Project Description

An overview of project purpose, scope and contract delivery systems.

B.2.1 Project Purpose

1) The end use and characteristics of the project.

B.2.2 Project Scope

(1) The planned and actual cost of the project;

(2) Total work hours for the design and construction activities;

(3) Overall schedule.

B.2.3 Contract Delivery System

(1) Nature of the contract and the type of contractor;

(2) Number and type of clients, and the extent of their involvement;

(3) Services provided by the client's representatives;

(4) Contractor's organisational structure and size.

B.3 Dimensions of Environment

(1) Stable-Dynamic:

Changes in client's requirements, shortages of skilled operatives, economic conditions, changes of project objectives.

(2) Simple-Complex:

Involvements of clients and their representatives, planning and control of the work, number and type of subcontractors.

(3) Friendly-Hostile:

Adverse relations between the involved parties, site location, weather conditions, competition.

B.4 Dimensions of Technology

(1) Certain-Uncertain:

Variability of work items and predictability of work activities.

(2) Simple-Complex:

Number of simultaneous work activities, applying unfamiliar designs or construction methods.

(3) Non-interdependent-Interdependent:

Extent to which work processes are interrelated such that changes in one affect the state of others, such as multiple constructionphases, physical congestion and equipment shortage.

B.5 Design Parameters

B.5.1 Design of Positions

Three parameters are identified for the design of individual positions within organisations.

(1) Specialisation - horizontal specialisation indicates the division of labour and allows individuals to be matched to the tasks, vertical

specialisation separates the performance of the work from the administration of the project.

(2) Formalisation - behaviour is formalised to reduce its variability and to bring about control. This is done by developing standard work methods, written rules and formal description of what steps to take in the job.

(3) Training and experience

B.5.2 Superstructure

Unit grouping and unit size are two concepts that provide the framework for understanding how positions are grouped into units and how large each unit is.

(1) Unit grouping - unit grouping is the fundamental means to coordinate work, since it establishes a system of common supervision among positions and units, creates common measure of performance and it requires positions and units to share common resources.

There are six bases of grouping:

(i) Grouping by knowledge and skill - positions may be grouped according to the specialised knowledge and skills that members bring to the job (e.g. different units may be created to house craftsmen of various skills).

(ii) Grouping by work processes - units may be formed according to the natural flow of the work and the required process interaction.

(iii) Grouping by output - units may be formed according to the products or services rendered.

(iv) Grouping by time - units may be formed on the basis of a schedule and the time sequence of the operation.

(v) Grouping by client - units may be formed to respond to needs of different types of clients.

(vi) Grouping by place - groups may be formed according to the geographical regions in which organisations operate.

(2) Unit size - defined in terms of three factors:

(i) Span of control and the number of employees reporting to their immediate supervisor;

(ii) Number of hierarchic levels and the number of management levels between chief executive and the operating core;

(iii) Number of personnel in the site organisation excluding the subcontractor's operatives.

B.5.3 Lateral Linkages

Planning and control systems and liaison devices together form the third design parameter.

(1) Planning and control systems - there are two kinds of planning and control systems; one that focuses on the regulation of overall performance and the other that seeks to regulate specific actions. The former is concerned primarily with after-the-fact monitoring of results and the latter is oriented towards specifying the required activities in advance.

(2) Liaison devices - when neither direct supervision nor standardisation are sufficient to achieve coordination, the organisation turns to other devices such as liaison positions, task forces and standing committees and integrating managers.

(i) Liaison positions - when a considerable amount of contact is necessary to coordinate the work of two or more units, a liaison position may be formally established to route the communications directly by avoiding the vertical channels. The position carries no formal authority.

(ii) Task forces and standing committees - task force is a committee formed to accomplish a particular task and disband after completion. Standing committee is a more permanent interdepartmental grouping, one that meets regularly to discuss issues of importance.

(iii) Integrating managers - an organisation may designate an integrating manager, which is a liaison position with formal authority. The position is superimposed on the old departmental structure and is given some of the power that formerly resided in the separate departments.

B.5.4 Decision-making systems

The decision-making systems, described by the degree of horizontal and vertical decentralisation and decision-making processes as defined by the behavioural and rational models, form the final design parameters.

(i) Horizontal decentralisation indicates the shift of power from line managers to staff managers, analysts and support specialists.

(ii) Vertical decentralisation indicates delegation of decision-making power down the chain of authority mainly within the line structure.

B.6 Interview questions

The following list of questions were used to obtain information and to help the non-directive interview back to its original track in case of any deviations.

(1) What were the major goals in structuring the site organisation?

(2) How did factors such as technology, size and project objectives influence the structure?

(3) What portions of the structure changed and what portions remained constant when these factors changed?

(4) Was it necessary to incorporate any unusual or unplanned elements in the structure?

(5) Was it necessary to set up any groups to protect construction operations from external influences?

(6) Did coordination requirements between the site members influence the formal patterns of communication?

(7) Were there any bottlenecks in communication flow that altered the original set-up?

(8) Did any alterations in project scope change the organisational structure?

(9) What was the effect of various phases in the site operation on the structure?

(10) Were there any changes in key personnel?

(11) Did portions of the structure evolve to conditions different from what was originally set?

(12) Have you used the present organisational structure before? How is this similar or different from the last job?

(13) What factors would you take into consideration in setting up the next project?

(14) Did you have to accept any compromises in structuring the organisation?

(15) Did you experience any uncertainties in the formation of the structure?

(16) Was it necessary to search for any alternative forms of organisation?

(17) How did normal company procedures influence the process of structuring?

(18) Was it possible to use past projects or company standards as starting points in structuring?

(19) Were there specific experiences on past projects which indicated that one structure performed better than others?

(20) Did any departments handle difficult tasks that were recognised by the organisation?

(21) Did any parts of the organisation contradict the basic project goals?

(22) What types of problems took the longest time to solve?

(23) What are your personal theories regarding the structuring of organisations?

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